WATERBIRD AND SHOREBIRD USE
AT
OCEAN ISLE BEACH IN BRUNSWICK COUNTY, NORTH CAROLINA

December 2001 - November 2002

Prepared for:

U. S. ARMY CORPS OF ENGINEERS
WILMINGTON DISTRICT
Wilmington, North Carolina

Contract No DACW 54-97-D-0028
Delivery Order 31

MAY 2003

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

Waterbird and Shorebird Use
at
Ocean Isle Beach in Brunswick County, North Carolina

1.0 INTRODUCTION

The U.S. Army Corps of Engineers (USACE), Wilmington District (Corps), has been involved with the Ocean Isle Beach Erosion and Hurricane Wave Protection Project which involved the placement of about 2 million cubic yards of sandy dredged material on the beachfront. The work was completed in three segments.

Segment 1 was a dune and berm fill extending from Station 51 + 50 to Station 103 + 00 (5,150 feet). The top of dune elevation was 9.5 feet National Geodetic Vertical Datum (NGVD), with a 50-foot-wide berm extending seaward from the dune toe. The constructed dune template tied into the existing dunes. The dune template started 40 feet inland from the natural vegetation line at elevation 7 feet NGVD. The landward slope of the dune was 5 horizontal to 1 vertical, the top of dune width was 25 feet, and the seaward slope was 10 horizontal to 1 vertical. The berm elevation was 7 feet NGVD. Below 7 feet NGVD, the with-project profile was assumed to parallel the natural profile out to a closure depth of -26 feet NGVD. The constructed dune was vegetated with American beachgrass and sea oats.

Segment 2 was the 50-foot berm portion of the main fill, and extended from Station 103 + 00 to Station 129 + 00 (2,600 feet). The berm-only templates (Segment 2 and Segment 3) extended seaward from the existing profile at elevation 7 feet NGVD. Below 7 feet NGVD, the with-project profile was assumed to parallel the natural profile out to a closure depth of -26 feet NGVD. Segment 3 was the 25-foot berm segment of the project, and extended from Station 129 + 00 to Station 153 + 00 (2,400 feet).

In addition to the main fill, the plan included a 4,200-foot-long transition on the east end, from Station 9 + 50 to Station 51 + 50; and a 2,800-foot-long transition on the west end, from Station 153 + 00 to Station 181 + 00. This gave a total project length (including transitions) of 17,150 feet, or about 3.25 miles. The project limits, including transition zones extended from Shallotte Boulevard on the eastern end of the island and proceeded westward to Duneside Street. The duration of the project was approximately four months. The constructed dune, including foreslope and backslope of the dune was planted with American beachgrass and sea oats.

Shorebirds and colonial waterbirds often use beach habitats for nesting, foraging, resting, and roosting. The purpose of this study was to monitor bird use of

these beach habitats and collect data to assess the impacts of beach renourishment on these birds. Surveys for this study began in March 2001 and concluded at the end of November 2002. This report summarizes information from surveys between December 2001 and 30 November 2002 (year two) and presents some analyses using all data collected.

1.1 Background Information. In recent years there has been increasing concern on the effects of habitat alteration and disturbance on selected waterbird groups. One of the most important factors to colonial nesting waterbirds is the availability of suitable, undisturbed nesting habitat. Many colonial nesting waterbirds (primarily Laridae and Rynchopidae) in North Carolina that once were dependent on nesting sites in association with ephemeral beach and inlet habitats are now dependent on selected dredged-material sites (Parnell and Soots 1975, Parnell and Shields 1990). The concentration of more birds nesting at fewer sites has increased the risk of catastrophic nesting failures. Human activities and predatory species present an increasing source of disturbance for nesting, feeding, and resting birds in all coastal habitats.

Shorebirds (primarily Haematopodidae, Charadriidae, and Scolopacidae) represent another group of waterbirds that has been the subject of recent concern and studies. Some shorebird species spend up to two-thirds of the year in migration and on wintering grounds (Burger 1984). Most shorebirds migrate between the Arctic tundra breeding grounds and South American wintering grounds. Recent studies have documented the importance of staging areas for these long-distance migrants (Myers et al. 1987, Clark et al. 1993, Hicklin 1987, Dodd and Spinks 2001). Many shorebirds take advantage of seasonally abundant food resources at these intermediate staging areas along their annual migratory cycle.

There is relatively little information on the effects of beach renourishment on bird populations. There has been one study in the general vicinity of the study area that includes a characterization of beach use by birds in three 1.5 km transects in New Hanover County (Smith 1988). Information on seasonal numbers and distribution of shorebirds on North Carolina's Outer Banks is available from over 123 km surveyed in 1992 and 1993 (Dinsmore et al. 1998). Abundance information is available on shorebird populations in Virginia (Watts and Truitt 2000) and South Carolina (Dodd and Spinks 2001). Most studies have concentrated on seasonal abundance, habitat use and identifying important staging areas. No detailed, comprehensive studies or data are available for bird use of beaches in Brunswick County, North Carolina.

2.0 STUDY AREA

Two transects were surveyed under the USACE Delivery Order for this portion of the study. Eleven additional transects were surveyed with the same protocol by CZR Incorporated under a separate work order (USACE Delivery Order #30, Contract DACW 54-97-D-0028). These eleven sites comprise 20km (13.75 miles) at sites between Cape Fear and Shallotte Inlet. Detailed results and information from these other eleven transects are found in a separate report, but some data from these sites are discussed herein in comparison to data from this study.

Transects covered all habitats from the primary dune to the intertidal/surf habitat. Transects were established to represent all habitat types in the study area and varied in length because an effort was made to cover all potentially suitable nesting habitats, especially in the vicinity of Shallotte Inlet. The western end of the Transect 12 is located near Shallotte Boulevard and the transect proceeds approximately1.7km (1 mile) westward along the eastern end of the island along Shallotte Inlet. Transect 13 extends 1.6km (1 mile) westward from Mt. Olive Street to near Monroe Street (Figure 1). Transects were referenced with numbers sequential to those surveyed east of Ocean Isle Beach (i.e., Transects 1 through 13) from east (Cape Fear) to west (Ocean Isle Beach). A summary of transect locations, features, and characteristics is found in Table 1. Coordinates along each transect were determined using a sub-meter accuracy global positioning system (GPS) and are referenced with visual features in Appendix A.

3.0 METHODS

3.1 Survey Seasons and Zones. Transects were identified as those subject to year-round surveys or those subject to non-breeding season surveys (Table 1). Transect 12 was surveyed year-round, because it contains potential nesting habitat. Transect 13 was surveyed during the non-breeding season. All transects were surveyed with the same frequency during the non-breeding season. Six additional surveys were conducted during the breeding season for Transect 12.

Surveys during the non-breeding season were conducted at different frequencies, based on known seasonal abundances of waterbirds and shorebirds in the region. Surveys were conducted weekly during migration (15 July to 30 November and 15 February to 30 May) and every other week during the mid-winter period (1 December to 15 February). Weekly surveys for breeding birds were conducted from 1 March through 15 July for the year-round transects. Since the breeding survey period overlaps the migration periods, surveys for both breeding and non-breeding use were combined for these periods of overlapping coverage.

Each transect was divided into three zones of microhabitat (intertidal/surf, beach, and dune areas), and four equally spaced zones along the longitudinal axis of the transects, represented as East, East-middle, West-middle, and West on the data sheet. Bird species and numbers were recorded in these zones along with the bird's activity (i.e., feeding, resting, flying, or breeding). Beach was defined as the area from the normal high water/tide (often denoted with the presence of a berm) to the toe of the primary dune. Overwash areas were included within the beach microhabitat. Any disturbances (e.g., people, pets, dredging, and predators) were also recorded.

3.2 Survey procedures. The duration of each survey varied among transects and within transects depending on the amount and type of habitat covered, and the number of birds present. All habitats including dunes, beach, and intertidal zones were surveyed in each transect. This was accomplished by walking parallel to the beach in most areas, but also required walking paths that zig-zagged across wider habitats. Transects were surveyed slowly and thoroughly to allow detection of all individuals of all species present and to insure that large mixed flocks of birds were thoroughly searched to locate, identify, and count all individuals of all species. Because all individuals were counted, the level of effort per km surveyed was considered equal for all transects.

Surveys were conducted during daylight hours between 30 minutes after sunrise to 30 minutes before sunset. Surveys were not conducted during poor weather conditions (heavy wind >25 mph, heavy rains, severe cold). Weather conditions including clouds, wind speed, wind direction, air temperature, and water temperature were recorded for each survey. Wind speed and air temperature were calculated using a Brunton Windwatch and wind direction was determined using a compass. Surf water temperatures were obtained from the *Wilmington Morning Star* newspaper. Tide times were recorded for each survey and were obtained from NOAA, National Service tide tables and corrected to the closest location where tidal correction times were provided. Each survey was categorized into one of two tidal categories (low or high) based on the time of the survey and the time to the closest low or high tide. Therefore, those surveys within $3\pm$ hours of high tide were classified as occurring at high tide. If a survey period included time from both categories, the survey was recorded in the category where more time was spent. This information along with the date, times of surveys, and location of each observation was recorded on a daily field data sheet.

Additional data on nesting species were recorded during the breeding season. These data included nesting chronology (e.g. dates when birds were first seen on the site, nest establishment dates, dates when unfledged chicks are present on the site), locations of the nests using GPS technology, locations of brood foraging territories for shorebirds, and known or suspected causes of nest and chick loss (e.g., pets, predators, and humans). Particular attention was concentrated in the vicinity of inlets,

which typically provide the best nesting habitat for shorebirds and colonial waterbirds. Potentially nesting plovers were watched with care, and suitable nesting habitat for plovers was thoroughly searched for any isolated nests. All sightings of Piping Plovers were reported to the USACE, U.S. Fish and Wildlife Service (USFWS), and N.C. Wildlife Resources Commission (NCWRC).

3.3 Statistical Analysis. Of interest was the effect of tide on abundance and richness. To test whether tide was a significant factor in either parameter, mean high tide and low tide abundance and richness were compared. The means were then analyzed for significant differences with a t-test, or, when appropriate, a Mann-Whitney test. Data were analyzed using SigmaStat Version 2.0.3 (SPSS Inc., Chicago, IL).

To test for possible effects of renourishment, data from these two renourished transects were compared with transects being surveyed with the same methodology under Delivery Order #30, Contract DACW 54-97-D-0028. Total abundance and species richness were the parameters used to examine the effects of beach replenishment. The possible effects of renourishment could differ for shorebird and waterbird species, therefore individuals were classified as waterbirds or shorebirds and analyzed separately. The data were further divided into beach and inlet transects due to potential differences in habitat use between shorebirds and waterbirds.

Little or no data were available for Transects 12 and 13 prior to renourishment. Consequently, any environmental impact could only be inferred from post-nourishment comparisons with control transects. Two unnourished inlet transects, Transect 7 (Oak Island - Lockwoods Folly Inlet) and Transect 8 (Holden Beach - Lockwoods Folly Inlet), were used as control transects for Transect 12 (Ocean Isle Beach - Shallotte Inlet). An unnourished beach transect, Transect 10 (Holden Beach - West Beach), was used as a control transect for Transect 13 (Ocean Isle Beach - East Beach).

Abundance and richness at renourished and control transects were compared using a two way analysis of variance (ANOVA) with year (first and second survey year) and area (control and renourished transect) as factors. For the ANOVA analysis, the multiple control areas for Transect 12 were not averaged for each sampling date, but rather each was considered a separate experimental unit under the Control group. However, it should be noted that the strength of statistical inferences was greatly limited by the fact that no pre-nourishment data were available. Significance was set at $\propto = 0.05$ for all statistical tests.

4.0 RESULTS AND DISCUSSION

4.1 Waterbird Species Richness. A summary of survey dates and corresponding survey week for all transects is found in Appendix B. Completed data sheets from

each survey are found in Appendix C. Twenty-six waterbird species were recorded from transect surveys during the second survey year (Table 2). Cumulative waterbird species richness was higher (26) at Transect 12 (Shallotte Inlet) and lower (15) at Transect 13 (East Beach). Mean number of waterbird species per km by transect ranged from 5.18 to 9.13 for all transects along the Brunswick County coastline. Mean number of waterbird species per km at Ocean Isle Beach was 8.39 at Shallotte Inlet and 5.50 at the beach transect (Table 3). During the second survey year, at Transect 12, species richness for waterbirds was highest in September and October and lowest in January and February (Figure 2). Overall, the monthly abundance at Transect 12 was similar in both survey years. Transect 13 had the lowest richness in late winter and early spring and the greatest richness in July and early winter (Figure 3). The total numbers of waterbird species recorded per survey by transect are found in Appendix D.

4.2 Waterbird Abundance. Presented in Table 3 is waterbird abundance (birds/km/survey) at all cape, beach, and inlet categories surveyed along the Brunswick County coastline. Mean number of waterbirds per km by transect ranged from 34.3 to 165.4 for all transects along the Brunswick County coastline. Waterbird abundance (birds/km/survey) was 65.6 at Transect 13 and 137.4 at Transect 12. Numbers of waterbirds at Transect 12 peaked for the year during fall migration (Figure 4). Transect 12 and 13 both experienced an increase in abundance in the spring; however, the fall migration was not as pronounced at Transect 13 as it was at Transect 12 (Figure 5). Waterbird numbers were lowest in late winter at both transects. The total numbers of individuals recorded per survey by transect are found in Appendix E.

The five most abundant waterbird species recorded were the Laughing Gull (*Larus atricilla*), Brown Pelican (*Pelecanus occidentalis*), Ring-billed Gull (*Larus delawarensis*), Royal Tern (*Sterna maxima*), and Herring Gull (*Larus argentatus)* (Table 4). Although all of these species are present in the study area in some numbers throughout most of the year, the Ring-billed Gull and Herring Gull are more common winter residents and the Laughing Gull is a much more common summer resident.

4.3 Shorebird Species Richness. Twenty-two shorebird species were recorded from the transects during the survey period (Table 5). Shorebird species richness was higher (22) at Transect 12 than at Transect 13 (10). Mean number of shorebird species per km by transect ranged from 1.95 to 4.78 for all transects along the Brunswick County coastline (Table 6). Mean number of shorebird species per km at Ocean Isle Beach was 4.43 at Transect 12 and 2.40 at Transect 13. Species richness for shorebirds was highest in May, August, and September at both transects (Figure 6 and Figure 7). Species richness for shorebirds was lowest in late winter and mid-summer. The total numbers of shorebird species recorded by transect are found in Appendix F.

4.4 Shorebird Abundance. Presented in Table 6 is shorebird abundance (birds/km/survey) at all cape, beach, and inlet categories surveyed along the Brunswick County coastline. Mean number of shorebirds per km by transect ranged from 8.0 to 63.4 for all transects along the Brunswick County coastline. Shorebirds were most abundant at Transect 12 (Shallotte Inlet) with 22.9 birds/km/survey and less abundant at Transect 13 (East Beach) with 13.7 birds/km/survey. Abundance patterns were similar to species richness. Numbers of shorebirds peaked during May and the fall migration, August through October (Figure 8 and Figure 9). Shorebird numbers were lowest in late winter and mid-summer. The total numbers of individuals recorded per survey by transect are found in Appendix G.

The five most abundant shorebird species recorded were the Sanderling (*Calidris alba*), Short-billed Dowitcher (*Limnodromus griseus*), Black-bellied Plover (*Plavialis squatarola*), Willet (*Catoptrophorus semipalmatus*), and Semipalmated Plover (*Charadrius semipalmatus*) (Table 7). Only one of the five most abundant shorebird species, the Willet, is a breeder in North Carolina. All remaining four species breed in tundra habitat in the far north and occur in North Carolina as migrants or winter residents.

4.5 Habitat Use. More waterbirds and shorebirds were recorded in the intertidal/surf zone compared to beach and dune habitats. Habitat use by waterbirds at Ocean Isle in each of the three zones, with corresponding percent of total recorded, was intertidal/surf with 64 percent, beach with 20 percent, and dune with 16 percent. Habitat use by shorebirds at Ocean Isle in each of the three zones, with corresponding percent of total recorded, was intertidal/surf with 85 percent, beach with 13 percent, and dune with 2 percent.

When considering the geographic position of the transects and evaluating habitat use in the categories of beach, inlet, and cape, waterbird activity was highest in the intertidal zone of all three categories. Almost 90 percent of all waterbird observations at Transect 12 were recorded in the intertidal zone (Table 8). Over 85 percent of all shorebird observations at the beach transect were recorded in the intertidal zone (Table 9). The highest percentage of beach use for waterbirds was recorded in beach transects and for shorebirds was recorded at inlet transects. It should be noted that habitat preference cannot be inferred since habitat use was not compared to habitat availability.

A comparison of all transects along the Brunswick County coastline showed the mean number of species encountered per survey was significantly higher for waterbirds ($p < 0.001$) and shorebirds ($p < 0.001$) at inlet transects compared to beach transects. Abundance (birds/km/survey) was higher for shorebirds at inlet transects compared to beach transects ($p = 0.002$). There was no significant difference for waterbird abundance between inlet and beach transects ($p = 0.938$).

4.6 Activity. Approximately 46 percent of all waterbird observations at Ocean Isle were associated with flying/migrating birds, 8 percent with feeding birds, 46 percent resting birds, and none with breeding activity (Table 10). Resting activity for waterbirds was higher (64.5 percent) at the inlet transect. Feeding activity was relatively low (less than 11 percent) for waterbirds at both transects.

Approximately 24 percent of all shorebird observations at Ocean Isle were associated with resting birds, 48 percent with feeding birds, 28 percent with flying/migrating birds, and less than 1 percent with breeding activity (Table 11). Resting activity for shorebirds was lower (13 percent) at the beach transect and higher (34.3 percent) at the inlet transect. Feeding activity for shorebirds was higher (60.2 percent) at the beach transect and lower (36.3 percent) at the inlet transect.

4.7 Nesting Birds. Signs of nesting were observed for American Oystercatcher (*Haematopus palliatus*) and Willet (*Catoptrophorus semipalmatus*) during the 2002 breeding season (Table 12). All nesting attempts and nests were in the vicinity of Shallotte Inlet. Although eggs were found from two nests, no successful hatching was documentated. Summary notes on nesting chronology on nesting and suspected nesting species are presented in Appendix H.

4.8 Observations of Disturbance. Almost all of the surveys at Ocean Isle Beach recorded a disturbance (Table 13). The average number of people encountered per survey was 31.2 at the inlet transect and 73.2 at the beach transect. Of the disturbances involving humans, fewer than 14 percent contained a disturbance with a dog. No disturbance from predators was noted, although gulls and hawks, which often prey on other birds, young, or eggs, were documented. The presence of dog, raccoon (*Procyon lotor*) and human tracks were relatively common in the vicinity of attempted nesting locations.

4.9 Effects of tide. Figures 10 and 11 depict waterbird abundance and richness by tide for the second survey year. At Transect 12 mean waterbird abundance at low tide 114.6 ± 108.3) was lower than mean high tide abundance (160.3 ± 194.6); however, the difference was not significant ($p = 0.429$). Mean waterbird richness at low tide (4.6 ± 1.4) was not significantly lower than richness at high tide (5.3 ± 1.3; $p = 0.084$). At Transect 13, mean low tide abundance (68.3 ± 43.4) was similar to mean high tide abundance (61.4 ± 29.0; $p = 0.868$). Mean low tide richness (3.6 ± 0.9) was similar to mean high tide richness (3.2 ± 1.1, $p = 0.303$).

Figures 12 and 13 depict shorebird abundance and richness by tide for the second survey year. At Transect 12 mean abundance of shorebirds at low tide (15.4 ± 22.0) was lower than mean high tide abundance (31.0 ± 43.7); however, the difference was not significant ($p = 0.069$). Low tide richness (1.9 ± 1.1) was significantly different from richness at high tide (3.3 ± 1.6; $p = 0.002$). For Transect 13, mean low tide abundance (12.4 ± 9.8) was not significantly lower than mean high

tide abundance (19.1 ± 19.8; $p = 0.141$). Mean shorebird richness at low tide (1.4 ± 0.7) was similar to richness at high tide (1.6 ± 0.9; $p = 0.516$).

4.10 Effects of Beach Renourishment on Waterbirds. Relative post nourishment abundance and species richness for Transect 12 and 13 and their respective controls are shown in Appendix I. For Transect 12, an ANOVA revealed no significant difference in abundance for the post- renourishment period ($p = 0.563$). In contrast, post-nourishment species richness at Transect 12 was significantly greater from the controls ($p < 0.001$). However, because no data are available for the before period, one cannot assume the post-nourishment relationship between Transect 12 and the control did not exist in the pre-renourishment period. Neither abundance nor richness at Transect 13 was significantly different from the control ($p = 0.492$ and 0.429, respectively). Overall, the data do not suggest that renourishment altered habitat use by waterbirds.

4.11 Effects of Beach Renourishment on Shorebirds. Relative post nourishment abundance and species richness for Transect 12 and 13 and their respective controls are shown in Appendix J. An ANOVA revealed no significant difference in post-nourishment abundance at transect 12 ($p = 0.056$). Although abundance at the control transects was higher than at Transect 12, an examination of weekly survey data did not suggest a consistent difference between the transects. Aside from some infrequent spikes in abundance at the control transects, abundance at Transect 12 and the controls was similar (Appendix J). Species richness at Transect 12 was significantly higher than richness at the control transects ($p < 0.001$). Data from Transect 13 are difficult to interpret. Both shorebird abundance and richness were higher at the control transect ($p < 0.001$ and 0.002), respectively. However, weekly survey data indicate that the difference may have resulted from high variability at the control transect.

4.12 Piping Plover Observations. Seven Piping Plovers (*Charadrius melodus*) were noted during the surveys, all from Transect 12 (Table 14). All were recorded feeding in the intertidal area in the vicinity of the inlet. No nesting attempts were noted, nor were any birds present during the breeding season.

5.0 SUMMARY

5.1 Species Richness and Abundance. A summary of species richness, abundance, habitat use, and recorded activity by all transects surveyed, including Transects 12 and 13, is found in Table 15 for waterbirds and Table 16 for shorebirds. Abundance and species richness for both shorebirds and waterbirds were generally greatest during fall and some of the spring months. The lowest abundance generally occurred in January and February and June and July. The mean number of species

encountered per survey was higher for waterbirds and shorebirds at Transect 12 compared to Transect 13. Abundance (birds/km/survey) of shorebirds and waterbirds was also highest at the inlet transect.

Compared to two other studies in North Carolina, the second-year data from Brunswick County are generally similar to a study conducted in New Hanover County in the mid 1980s (Smith 1988). The top four most abundant waterbird species were the same at Ocean Isle Beach compared to New Hanover County. Four of the top five shorebird species were the same between the two studies. Only the Dunlin (*Calidris alpina*) was not in Ocean Isle Beach's top five most abundant shorebird species.

5.2 Effects of Tide. Tide influenced richness and abundance at Ocean Isle. At Transect 12 (Shallotte Inlet) greater numbers of waterbirds individuals and species were surveyed at high tide compared to low tide, but the difference was not significant. In contrast, waterbird richness and abundance at Transect 13 (Ocean Isle Beach) was similar at high and low tide. Shorebird abundance and species richness were greater during high tide at both transects, but a significant difference was found for shorebird richness at Transect 12 only.

5.3 Effects of Beach Renourishment. For Transects 12 and 13, only post-nourishment data were used in statistical comparisons. Compared to Transect 12, waterbird richness, but not abundance, was significantly higher at the renourished transect. For Transect 13, neither waterbird abundance or richness were significantly different from control areas. At Transect 12, shorebird richness, but not abundance, was significantly greater than at the controls. Both shorebird richness and abundance at Transect 13 were significantly lower than the control, but these results may have resulted from high variability at the control transect.

Beach renourishment has the potential to affect avian beach communities in a number of ways. The increase in beach area after renourishment could attract birds and increase shorebird and waterbird abundance. Alternately, avian abundance could decrease if food resources and/or availability are reduced in the post-renourishment period. These same changes could also lower species diversity if specialist feeders make less frequent visits to renourished beaches with disturbed benthic habitat. In addition to population changes, renourishment could alter bird behavior and habitat use as well.

Despite the potential for community changes at renourished beaches, in this study, no consistent data trends in post-renourishment surveys were apparent. Also, without population data for the weeks preceding renourishment, one could not determine whether relative population differences in the post-renourishment period were due to renourishment effects or whether there were pre-existing differences in richness and abundance. Overall, however, there was not strong evidence for significant alterations in avian abundance and richness after beach renourishment.

6.0 REFERENCES

Berger, J. 1984. Shorebirds as marine animals, p. 17-81. In J. Berger and B.L. Olla [eds.], Behavior of marine animals, vol. 5: Shorebirds: breeding behavior and populations. Plenum Press, New York.

Clark, K. E., L. J. Niles, and J. Burger. 1993. Abundance and distribution of migrant shorebirds in Delaware Bay. The Condor 95:694-705.

Dinsmore, S. J., J. A. Collazo, and J. R. Walters. 1998. Seasonal numbers and distribution of shorebirds on North Carolina's Outer Banks. Wilson Bulletin 110:171-181.

Dodd, S. L. and M. D. Spinks. 2001. Shorebird assemblages of the Cape Romain Region, South Carolina. The Chat 65:45-67.

Hicklin, P. W. 1987. The migration of shorebirds in the Bay of Fundy. Wilson Bulletin 99:540-570.

Myers, J. P., R. I. G. Morrison, P. Z. Antas, B. A. Harrington, T. E. Lovejoy, M. Salaberry, S. E. Senner, and A. Tarak. 1987. Conservation strategy for migratory species. American Science 75:18-26.

NOAA. Tide tables were obtained from the National Service tide tables. http://co-ops.nos.noaa.gov

Parnell, J. F., and R. F. Soots. 1975. Proceedings of a conference on management of dredge islands in North Carolina estuaries. UNC Sea Grant Publication. UNC-SG-75-01.

Parnell, J. F., and M. A. Shields. 1990. Management of North Carolina's Colonial Waterbirds. UNC Sea Grant Publication. UNC-SG-90-03.

Schroeter, S. C., J. D. Dixon, J. Kastendiek, and R. O. Smith. 1993. Detecting the ecological effects of environmental impacts: a case study of kelp forest invertebrates. Ecological Applications 3:331-350.

Smith, A. P. 1988. A characterization of beach use by birds in southeastern North Carolina. M.S. thesis, University of North Carolina at Wilmington, Wilmington, North Carolina.

Stewart-Oaten, A., W. W. Murdoch. 1986. Environmental impact assessment: "pseudoreplication" in time? Ecology 67:929-940.

SSPS Inc. 233 South Wacher Drive 11th Floor, Chicago, IL 60606-6307. SigmaStat 2.0.3 for windows. www.sspscience.com

Watts, B. D. And B. R. Truitt. 2000. Abundance of shorebirds along the Virginia Barrier Islands during spring migration. The Raven 71:33-39.

Wilmington Star News. 1003 S. 17th Street, Wilmington, NC 28402. Surf water temperatures are obtained daily from the surf forecast section. www.wilmingtonstar.com

FIGURES

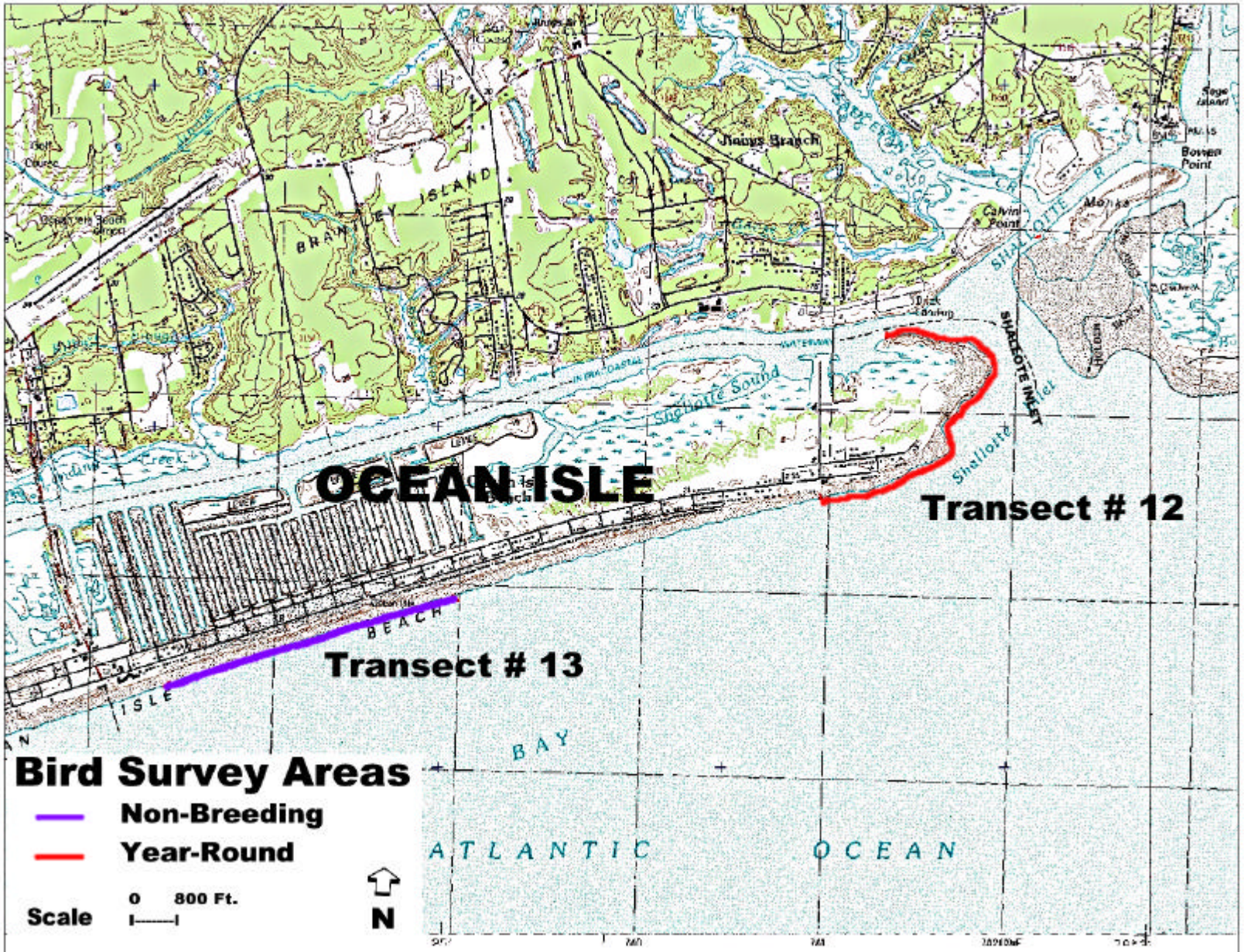


Figure 1. Location of Transects 12 and 13 on Ocean Isle, Brunswick County, N.C.

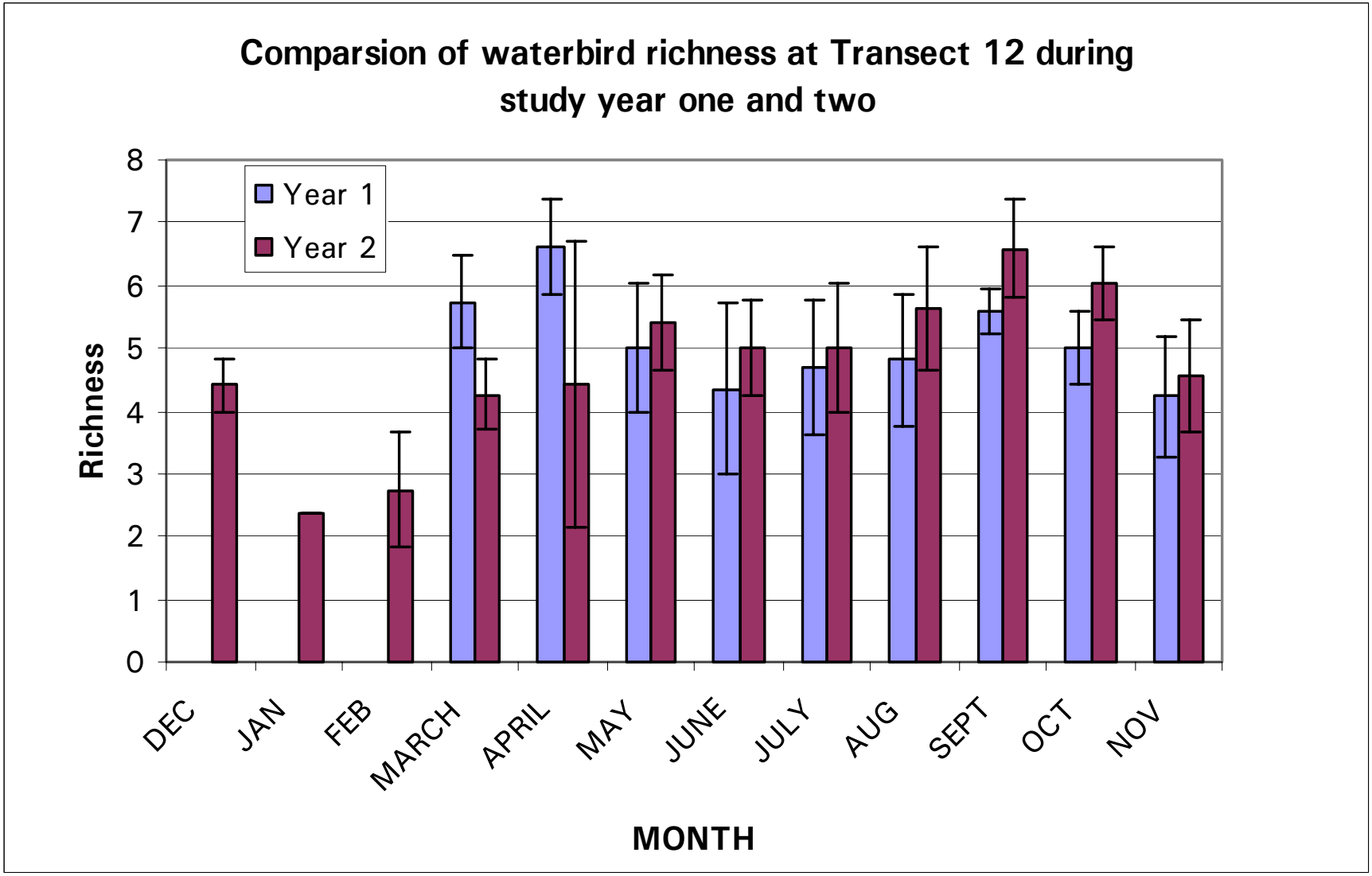


Figure 2. Comparison of waterbird richness at Transect 12 during study year one (study began in March 2001) and two.

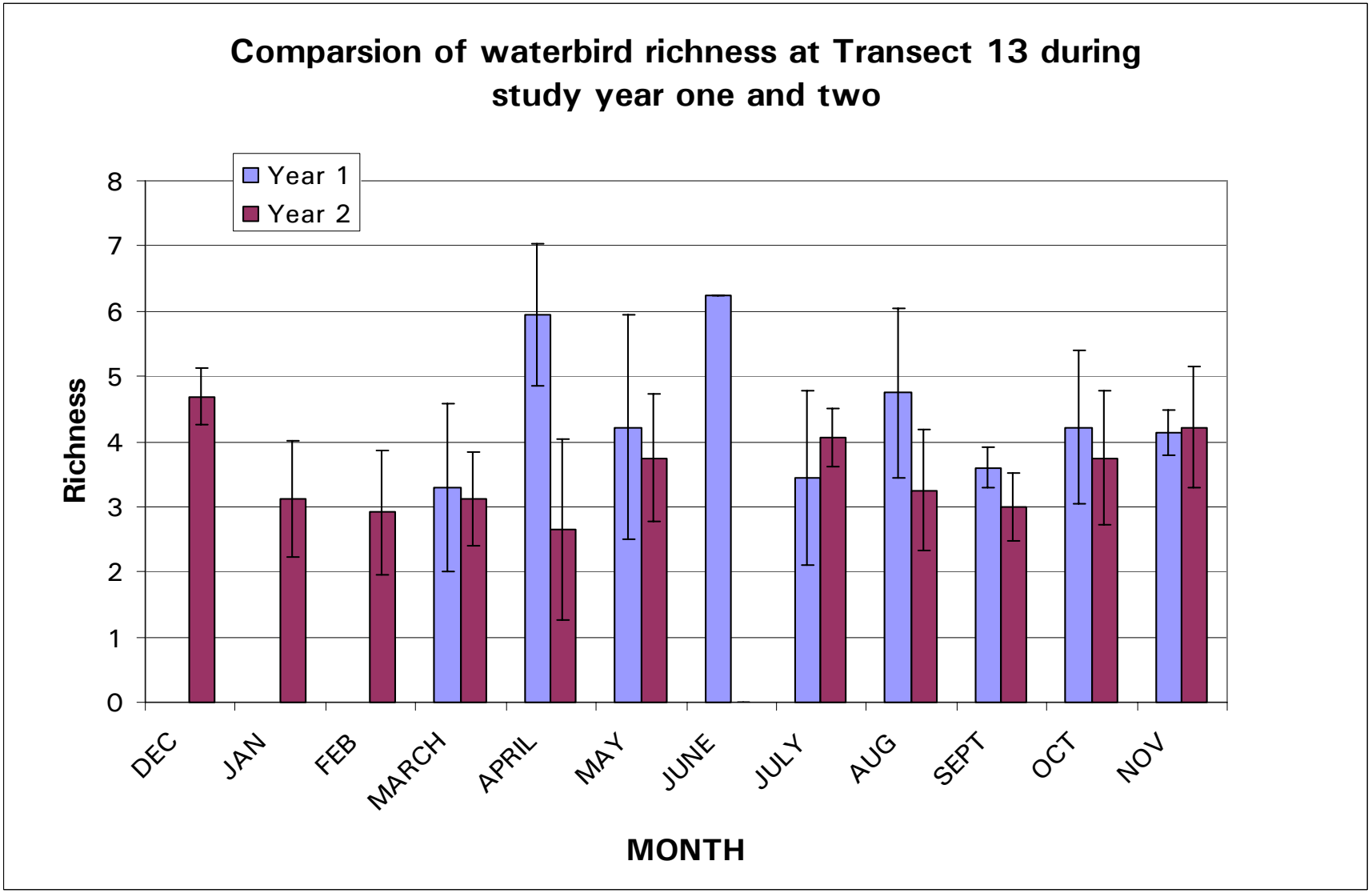


Figure 3. Comparison of waterbird richness at Transect 13 during study year one (study began in March 2001) and two.

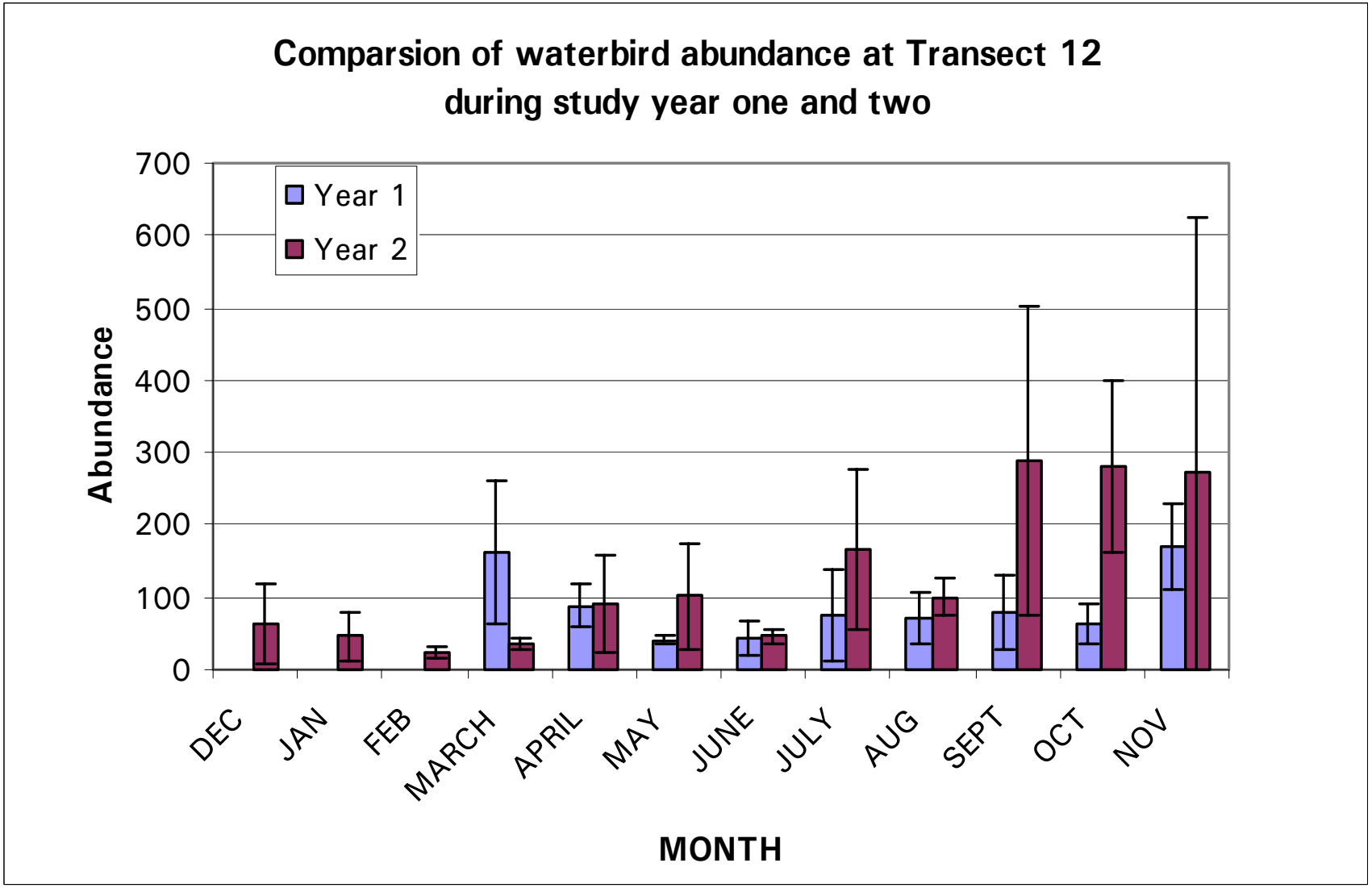


Figure 4. Comparison of waterbird abundance at Transect 12 during study year one (study began in March 2001) and two.

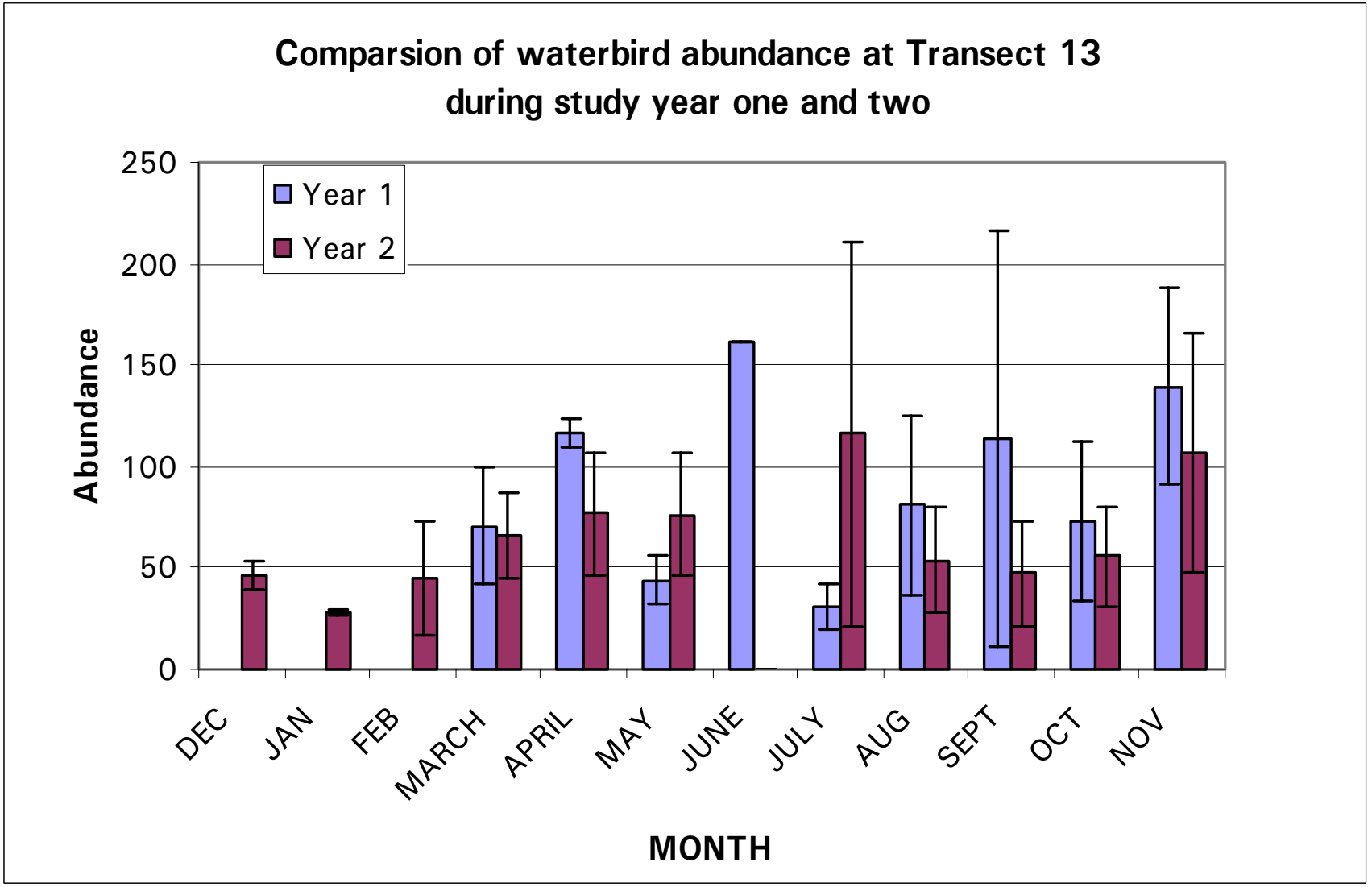


Figure 5. Comparison of waterbird abundance at Transect 13 during study year one (study began in March 2001) and two.

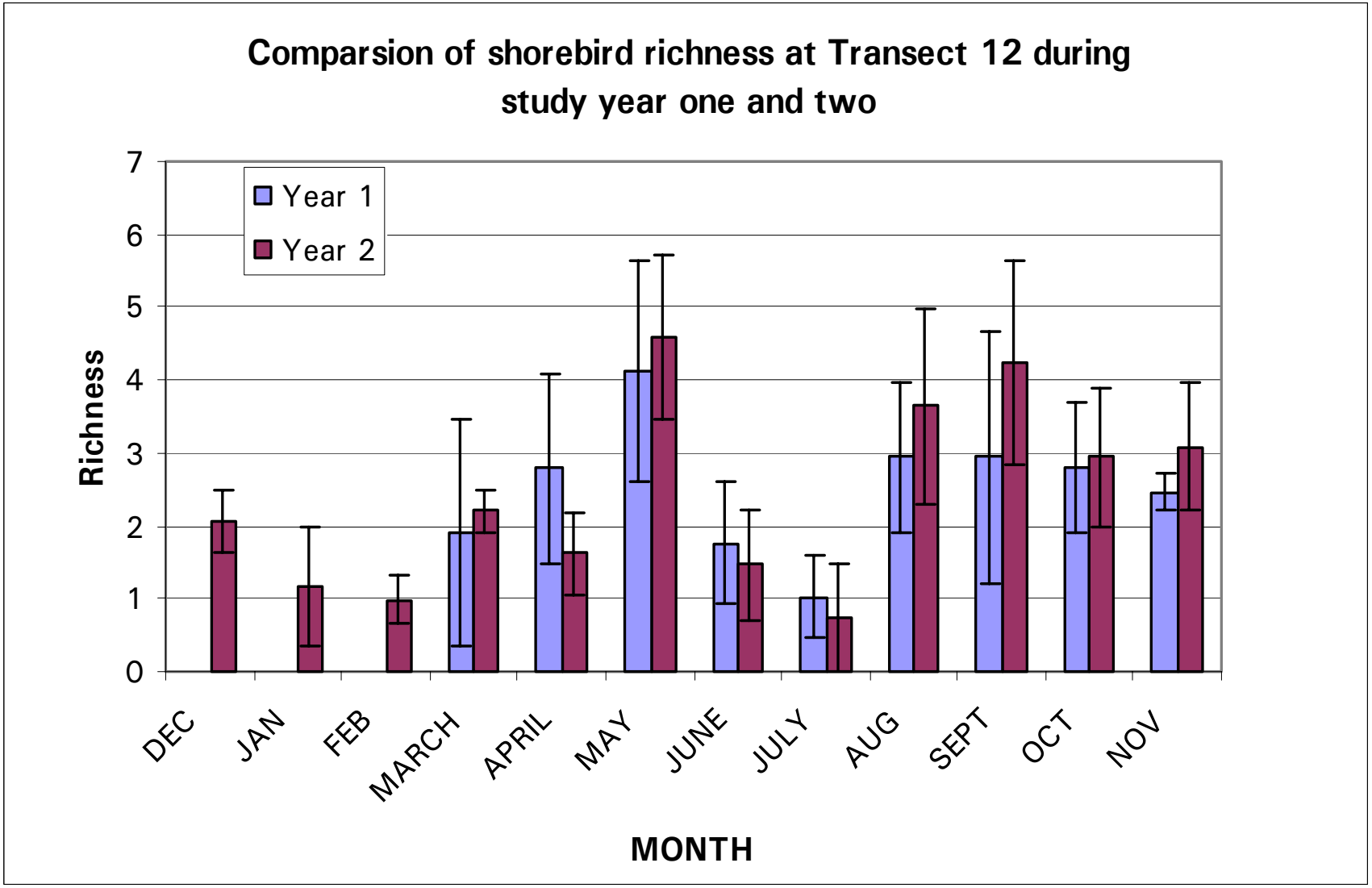


Figure 6. Comparison of shorebird richness at Transect 12 during study year one (study began in March 2001) and two.

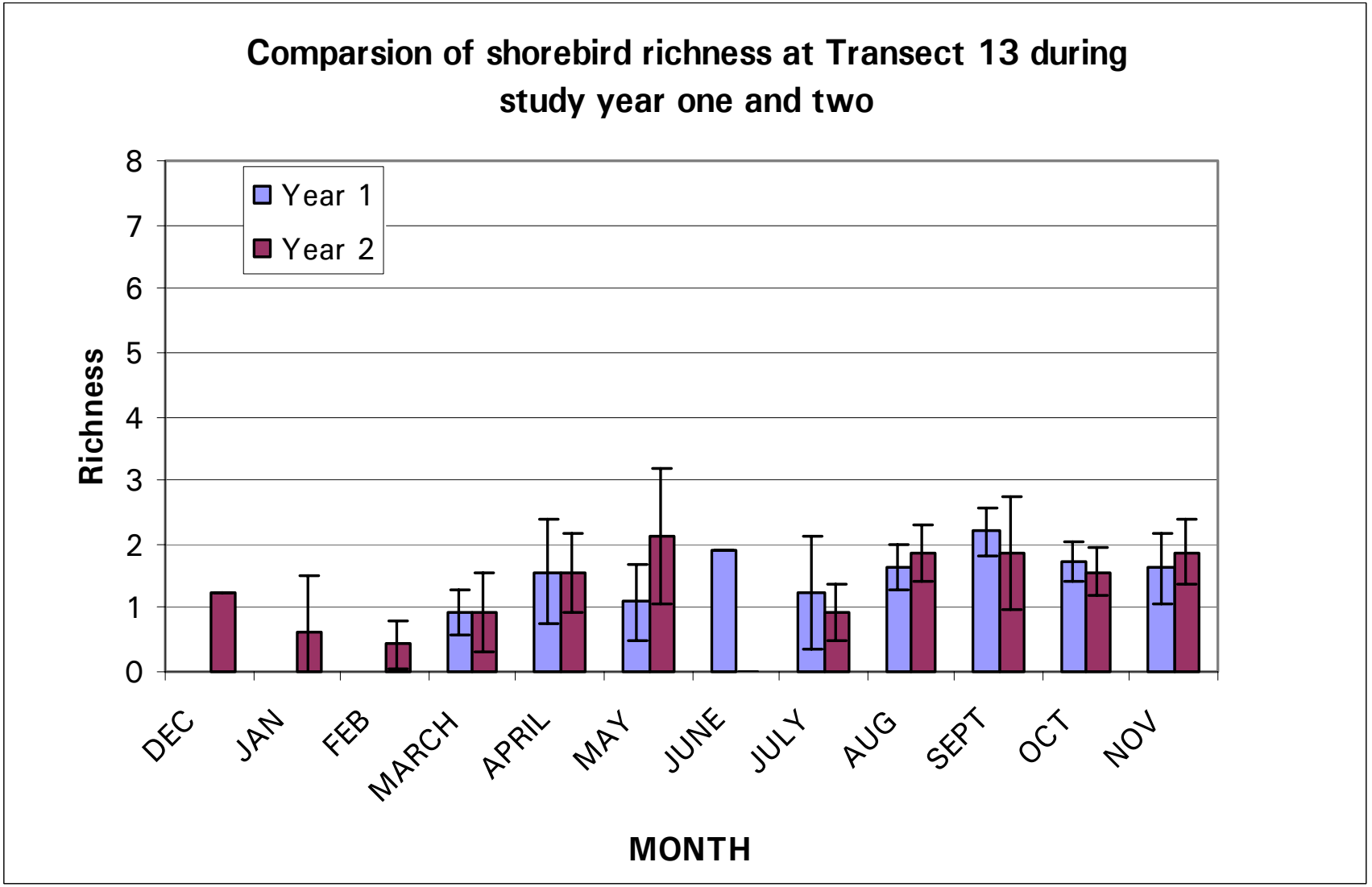


Figure 7. Comparison of shorebird richness at Transect 13 during study year one (study began in March 2001) and two.

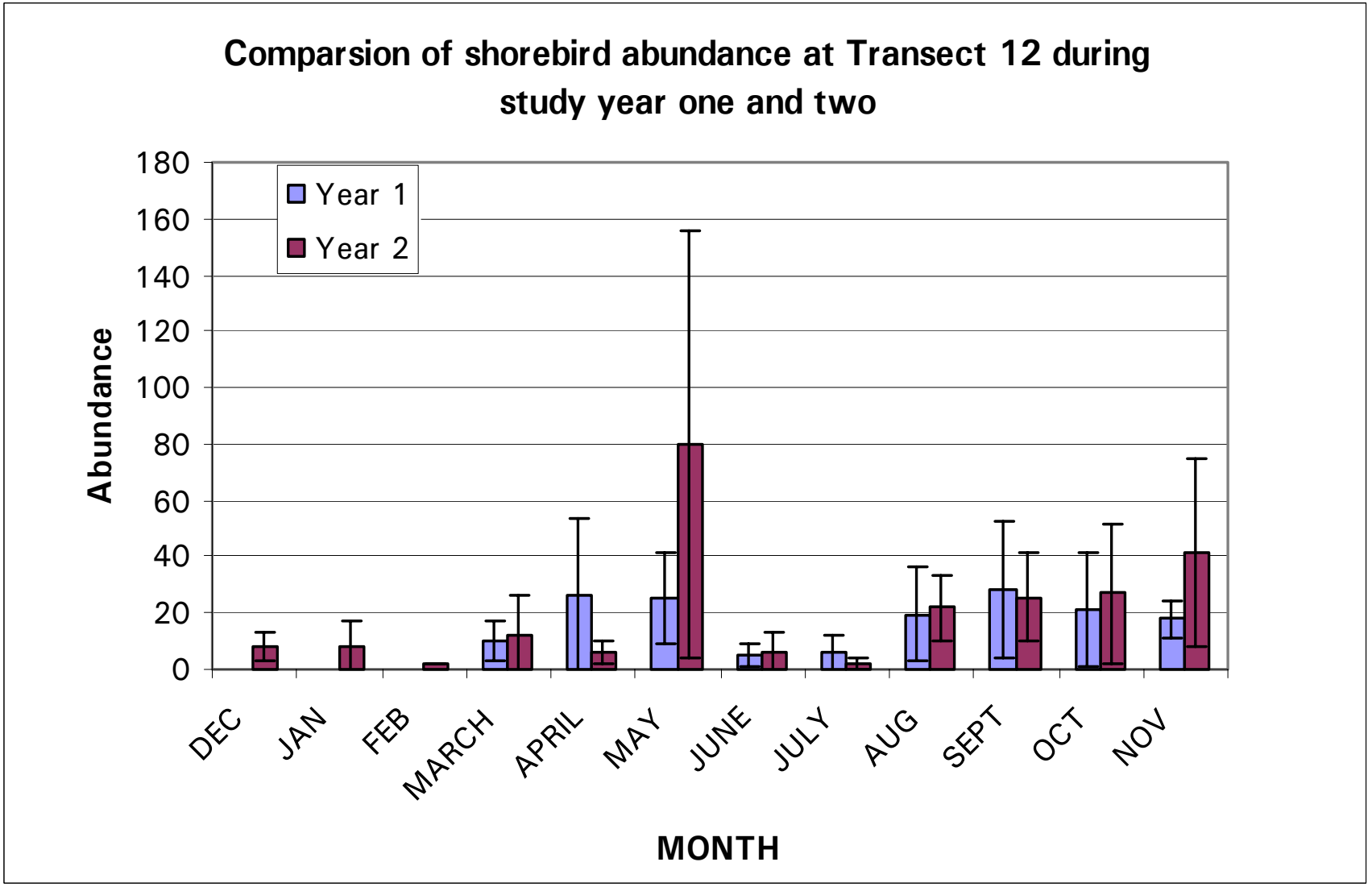


Figure 8. Comparison of shorebird abundance at Transect 12 during study year one (study began in March 2001) and two.

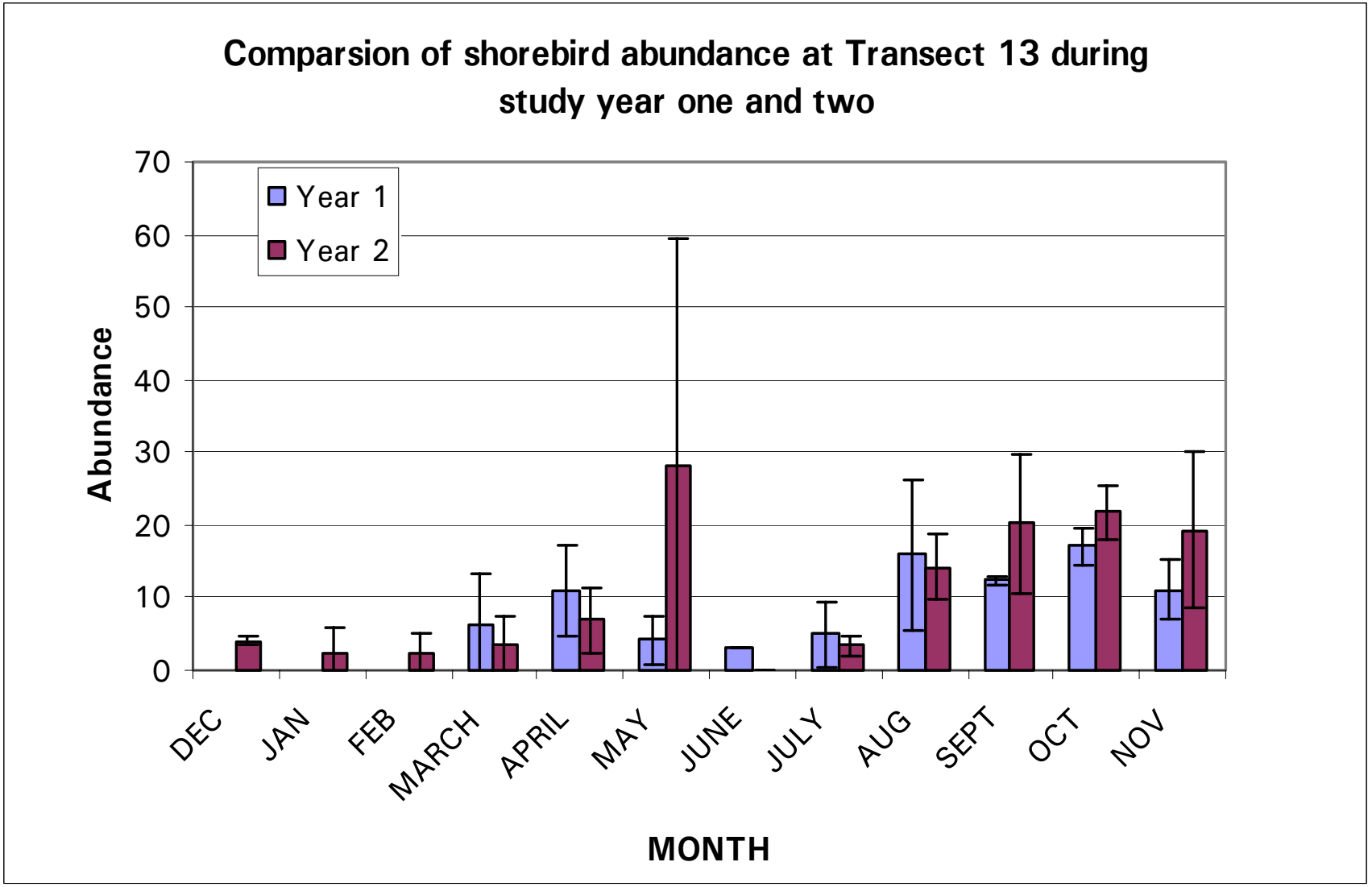


Figure 9. Comparison of shorebird abundance at Transect 13 during study year one (study began in March 2001) and two.

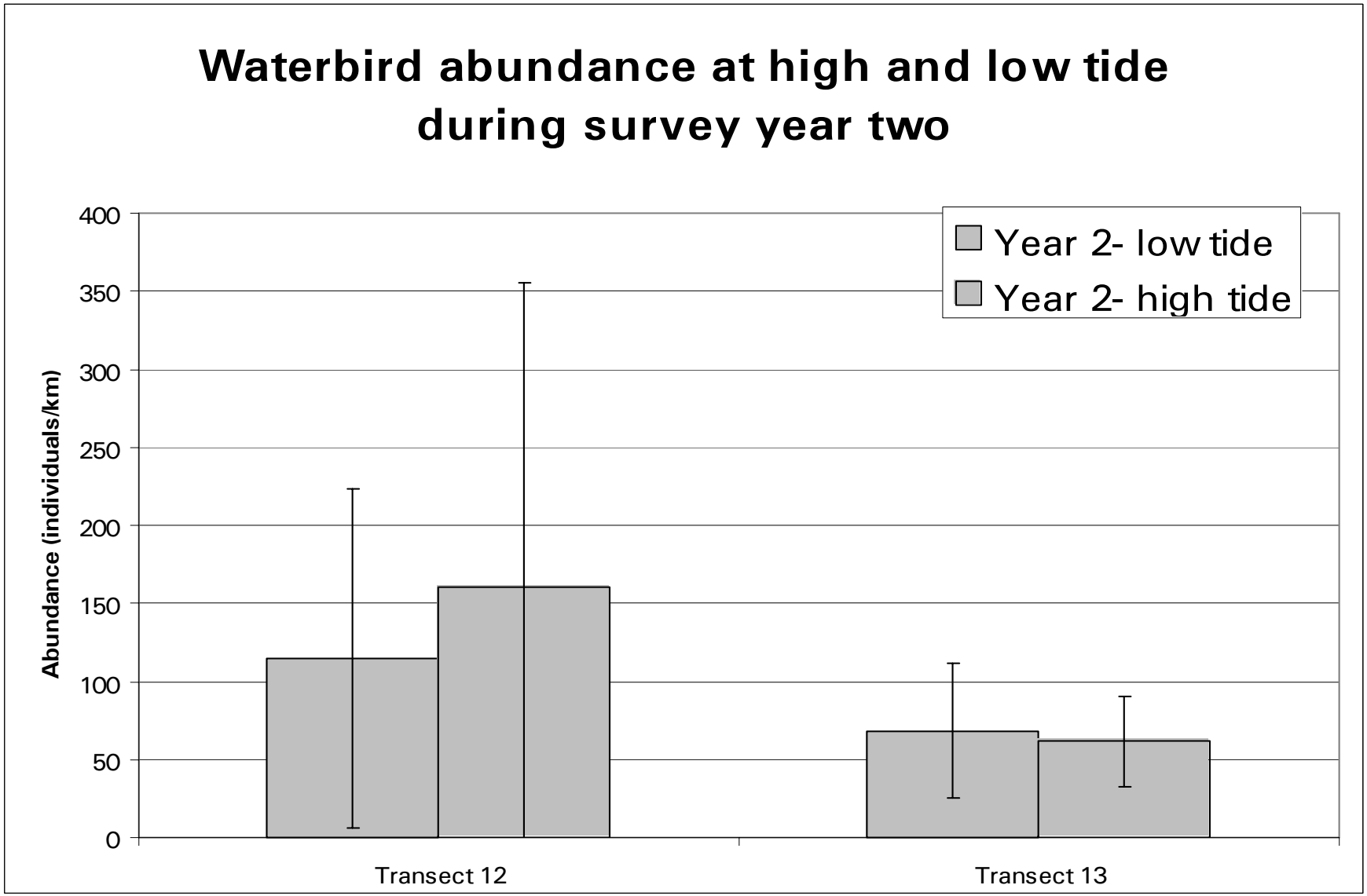


Figure 10. Waterbird abundance at high and low tide during survey year two.

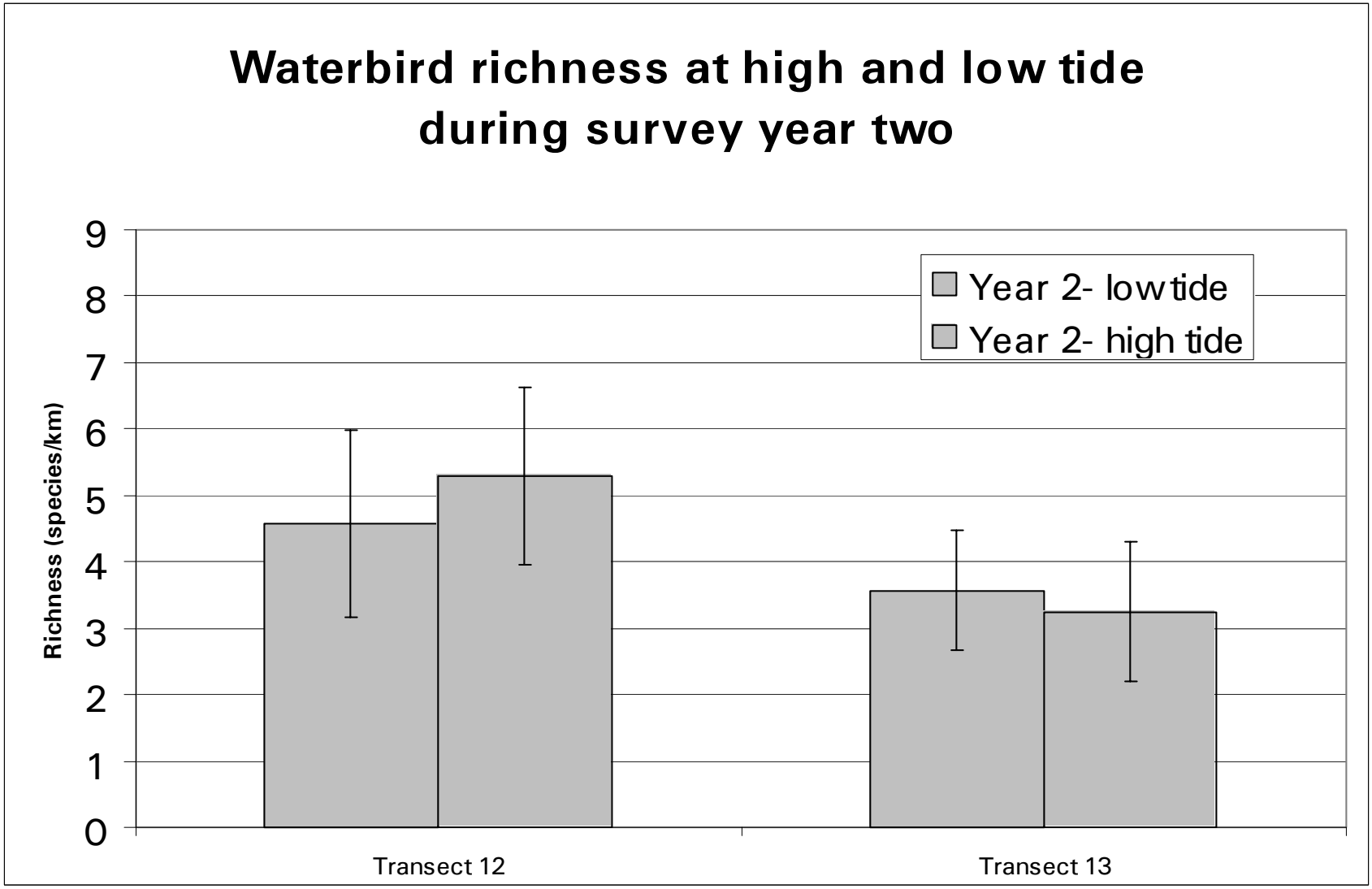


Figure 11. Waterbird richness at high and low tide during survey year two.

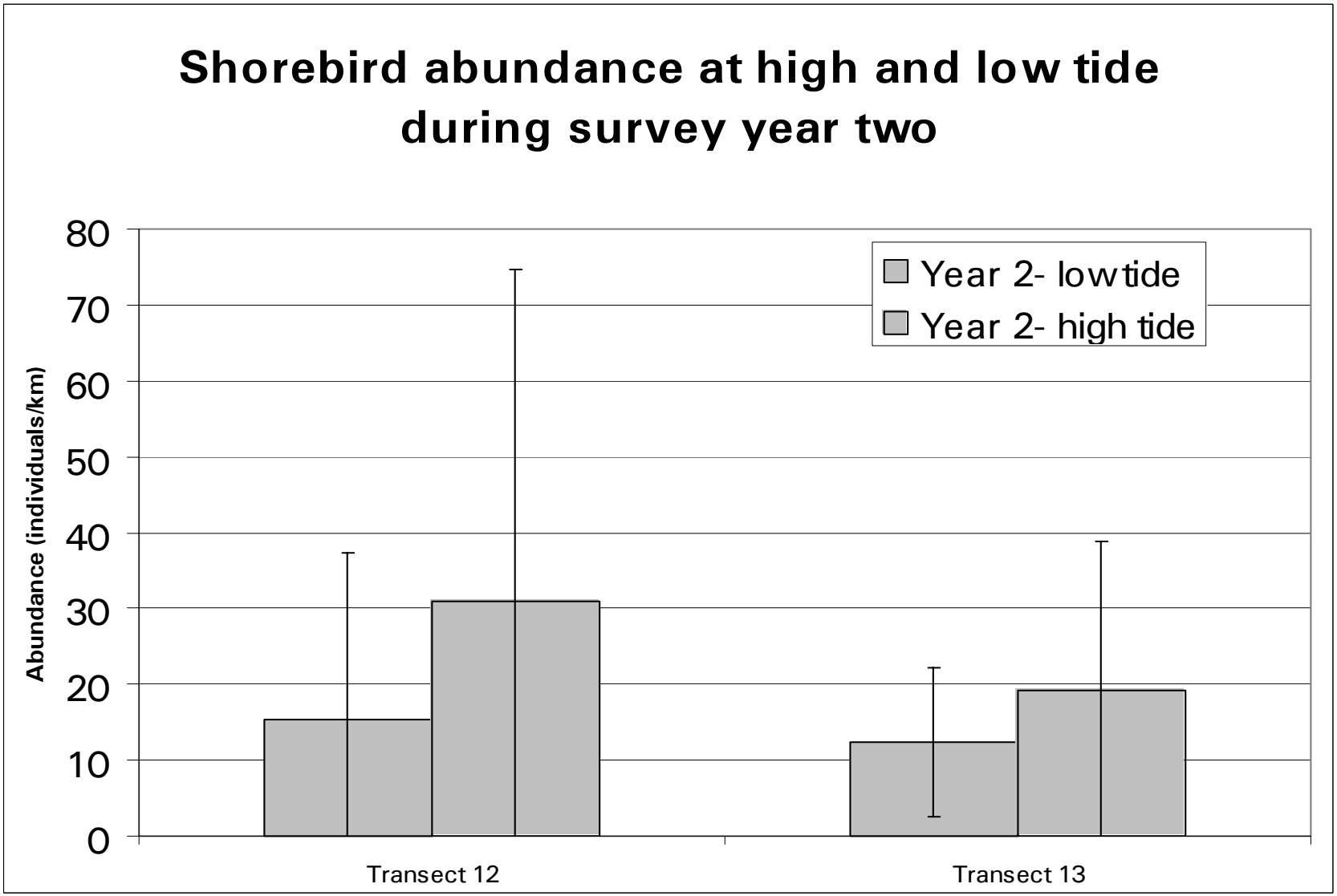


Figure 12. Shorebird abundance at high and low tide during survey year two.

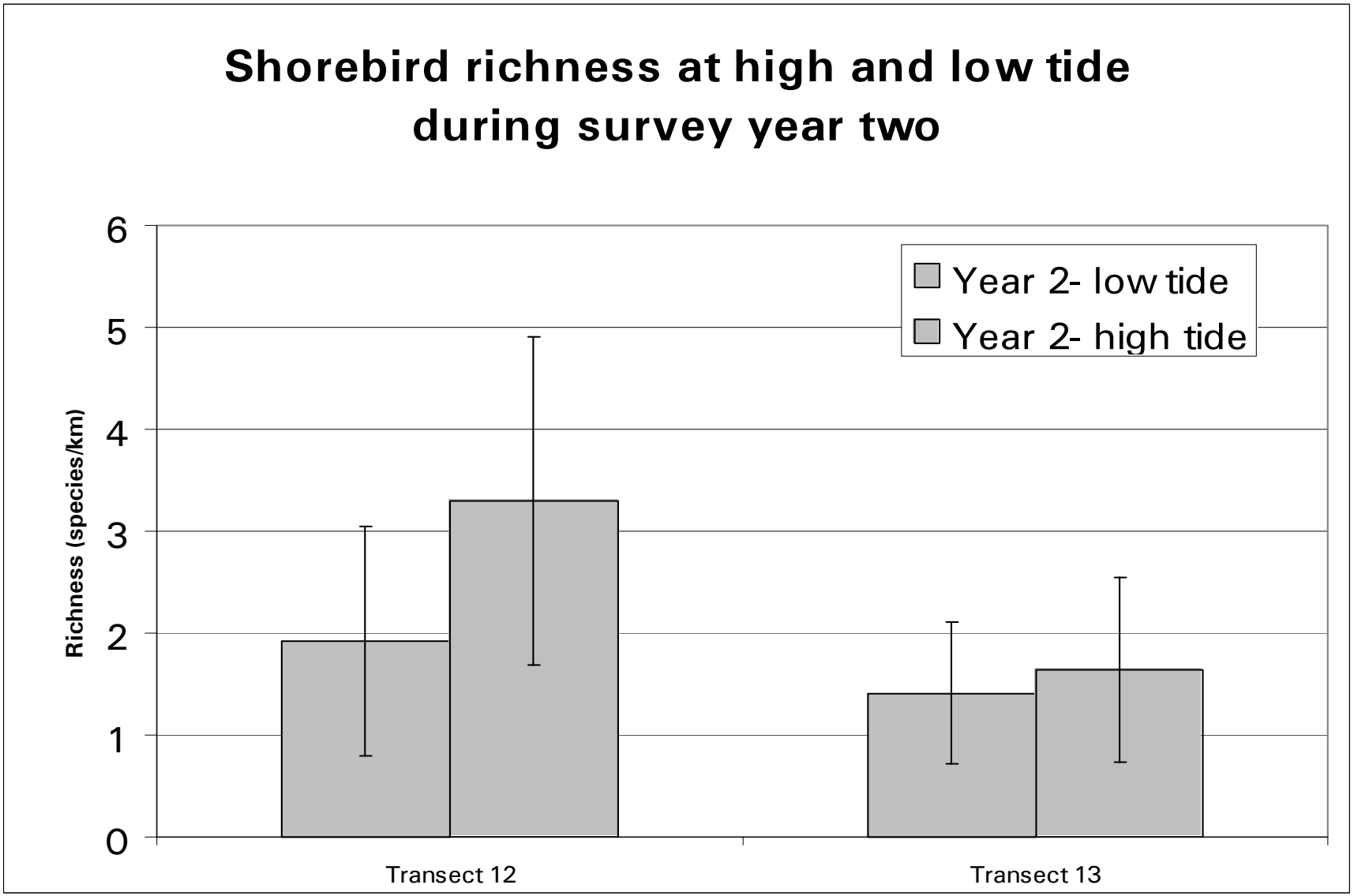


Figure 13. Shorebird richness at high and low tide during survey year two.

TABLES

Table 1. Summary of transect locations, features, and characteristics for Ocean Isle Beach bird surveys.

Transect #	Island	Site	Length (km)	# of Surveys	Frequency of surveys	Renourishment
12	Ocean Isle Beach	Inlet	1.7	46	year-round	March 2001 (partial)
13	Ocean Isle Beach	Beach	1.6	40	non-breeding	April 2001

Table 2. Total waterbird individuals recorded for each species in each transect.

SPECIES	12	13	Grand Total
Laughing Gull	1,549	1,524	3,073
Brown Pelican	2,426	582	3,008
Ring-billed Gull	1,291	1,436	2,727
Royal Tern	1,767	56	1,823
Herring Gull	738	284	1,022
Common Tern	670	4	674
Sandwich Tern	630	28	658
Forster's Tern	576	35	611
Great Black-backed Gull	337	114	451
Caspian Tern	231	18	249
Bonaparte's Gull	104	75	179
Double-crested Cormorant	137	25	162
Least Tern	95	12	107
Black Skimmer	85	0	85
Black Tern	28	0	28
White Ibis	26	0	26
Great Egret	15	0	15
Lesser Black-backed Gull	10	1	11
Red-breasted Merganser	10	0	10
Great Blue Heron	7	0	7
Tricolored Heron	6	0	6
Red-throated Loon	1	3	4
Northern Gannet	3	0	3
Snowy Egret	2	0	2
Little Blue Heron	2	0	2
Common Loon	1	0	1
Total individuals	10,747	4,197	14,943
Total species	26	15	26

Table 3. Waterbird richness and abundance.

Site	Transect	Species	Average number of species/survey	Average number of birds/km/survey
Cape	1	**27**	**7.37**	**153.4**
Beach	2[a]	16	5.18	34.3
	5[a]	22	6.80	165.4
	6	15	6.00	157.9
	9[a,b]	18	6.08	114.7
	10	18	5.83	84.1
	13[a,c]	15	5.50	65.6
	Average	**17.3**	**5.90**	**103.7**
Inlet	3[a]	25	7.28	94.7
	4	23	7.58	95.9
	7	22	7.76	120.4
	8[b]	22	7.17	125.1
	11	29	9.13	60.0
	12[a,c]	26	8.39	137.4
	Average	**24.5**	**7.89**	**105.6**

[a] Renourished during 2001.
[b] Renourished during 2002.
[c] Transect at Ocean Isle.

Table 4. Most abundant waterbirds per survey per km (Transects 12 and 13).

Waterbird species	Beach	Inlet
Laughing Gull	23.7	19.8
Brown Pelican	9.0	31.0
Ring-billed Gull	22.3	16.5
Royal Tern	0.9	22.6
Herring Gull	4.4	9.4
Common Tern	0.1	8.6
Sandwich Tern	0.4	8.1
Forster's Tern	0.5	7.4
Great Black-backed Gull	1.8	4.3
Caspian Tern	0.3	3.0
Double-crested Cormorant	0.4	1.8

Table 5. Total numbers of shorebird individuals recorded for each species in each transect.

	Transect #		
SPECIES	12	13	Grand Total
Sanderling	399	504	903
Short-billed Dowitcher	399	3	402
Black-bellied Plover	321	21	342
Willet	102	166	268
Semipalmated Plover	174	0	174
Semipalmated Sandpiper	60	90	150
Ruddy Turnstone	90	25	115
American Oystercatcher	37	15	52
Dunlin	52	0	52
Whimbrel	49	0	49
Killdeer	7	38	45
Pectoral Sandpiper	19	0	19
Least Sandpiper	9	9	18
Wilson's Plover	16	0	16
Lesser Yellowlegs	16	0	16
Red Knot	10	2	12
Spotted Sandpiper	8	0	8
Piping Plover	7	0	7
Western Sandpiper	6	0	6
Greater Yellowlegs	4	0	4
Long-billed Dowitcher	3	0	3
Long-billed Curlew	1	0	1
Buff-breasted Sandpiper	0	1	1
Total individuals	1,789	874	2,663
Total species	22	10	22

Table 6. Shorebird richness and abundance.

Site	Transect	Species	Average number of species/survey	Average number of birds/km/survey
Cape	1	**14**	**2.59**	**15.5**
Beach	2[a]	10	1.95	8.0
	5[a]	14	2.68	10.7
	6	10	2.28	10.6
	9[a,b]	10	2.83	10.6
	10	11	2.93	16.3
	13[a,c]	10	2.40	13.7
Avera			**2.51**	**11.7**
Inlet	3[a]	14	3.91	33.5
	4	14	3.40	20.3
	7	20	4.22	63.4
	8[b]	14	3.07	32.7
	11	18	4.78	26.2
	12[a,c]	22	4.43	22.9
Average			**3.97**	**33.2**

[a] Renourished during 2001.
[b] Renourished during 2002.
[c] Transect at Ocean Isle.

Table 7. Most abundant shorebirds per survey per km (Transects 12 and 13).

Waterbird species	Beach	Inlet
Sanderling	5.1	7.9
Short-billed Dowitcher	5.1	0.0
Black-bellied Plover	4.1	0.3
Willet	1.3	2.6
Semipalmated Plover	2.2	0.0
Semipalmated Sandpiper	0.8	1.4
Ruddy Turnstone	1.2	0.4
American Oystercatcher	0.5	0.2
Killdeer	0.1	0.6
Dunlin	0.7	0.0

Table 8. Percentage of total waterbird individuals recorded by habitat and transect.

Site	Transect	Intertidal	Beach	Dune
Cape	1	**78.5**	**19.6**	**1.9**
Beach	2[a]	73.0	10.5	16.5
	5[a]	55.7	29.6	14.7
	6	57.7	27.3	15.0
	9[a,b]	64.0	21.8	14.2
	10	57.6	20.4	22.0
	13[a,c]	40.1	33.5	26.4
Average		**58.0**	**23.9**	**18.1**
Inlet	3[a]	79.0	14.0	7.0
	4	89.0	3.9	7.1
	7	67.1	21.6	11.3
	8[b]	72.2	13.8	14.0
	11	85.4	7.1	7.5
	12[a,c]	87.5	7.1	5.4
Average		**80.0**	**11.3**	**8.7**

[a] Renourished during 2001.
[b] Renourished during 2002.
[c] Transect at Ocean Isle.

Table 9. Percentage of total shorebird individuals recorded by habitat and transect.

Site	Transect	Intertidal	Beach	Dune
Cape	1	**94.6**	**5.2**	**0.2**
Beach	2[a]	95.1	3.3	1.6
	5[a]	83.8	15.9	0.3
	6	80.1	18.4	1.5
	9[a,b]	86.6	13.1	0.3
	10	87.9	9.6	2.5
	13[a,c]	85.7	10.1	4.2
Average		**86.5**	**11.7**	**1.7**
Inlet	3[a]	73.2	26.5	0.3
	4	96.6	2.4	1.0
	7	54.8	44.9	0.3
	8[b]	80.6	18.7	0.7
	11	69.6	27.6	2.8
	12[a,c]	84.0	15.3	0.7
Average		**76.5**	**22.6**	**1.0**

[a] Renourished during 2001.
[b] Renourished during 2002.
[c] Transect at Ocean Isle.

Table 10. Percentage of total waterbird individuals recorded by activity and transects.

Site	Transect	Resting	Feeding	Flying	Breeding
Cape	1	**55.9**	**7.4**	**36.7**	**0.0**
Beach	2[a]	26.8	11.9	61.3	0.0
	5[a]	51.1	7.3	41.6	0.0
	6	54.1	8.1	37.8	0.0
	9[a,b]	47.6	11.1	41.3	0.0
	10	42.8	8.1	49.1	0.0
	13[a,c]	27.0	10.0	63.0	0.0
Average		**41.6**	**9.4**	**49.0**	**0.0**
Inlet	3[a]	60.3	4.5	35.2	0.0
	4	57.4	6.6	36.0	0.0
	7	57.7	4.9	37.4	0.0
	8[b]	42.4	6.4	51.2	0.0
	11	49.1	7.5	43.4	0.0
	12[a,c]	64.6	6.1	29.3	0.0
Average		**55.3**	**6.0**	**38.8**	**0.0**

[a] Renourished during 2001.
[b] Renourished during 2002.
[c] Transect at Ocean Isle.

Table 11. Percentage of total shorebird individuals recorded by activity and transect.

Site	Transect	Resting	Feeding	Flying	Breeding
Cape	1	**11.3**	**76.2**	**12.4**	**0.1**
Beach	2[a]	9.6	75.7	14.7	0.0
	5[a]	11.4	75.7	12.6	0.3
	6	12.4	67.1	20.5	0.0
	9[a,b]	17.4	70.6	12.0	0.0
	10	16.8	69.5	13.7	0.0
	13[a,c]	13.0	60.2	26.8	0.0
Average		**13.4**	**69.8**	**16.7**	**0.1**
Inlet	3[a]	54.2	34.8	10.9	0.1
	4	60.6	31.4	7.7	0.3
	7	75.0	16.4	8.5	0.1
	8[b]	66.4	24.9	8.7	0.0
	11	55.8	27.6	16.5	0.1
	12[a,c]	34.3	36.3	29.3	0.1
Average		**57.7**	**28.6**	**13.6**	**0.1**

[a] Renourished during 2001.
[b] Renourished during 2002.
[c] Transect at Ocean Isle.

Table 12. Signs of breeding birds along Transects 12 and 13, Ocean Isle, N.C. during 2002.

Species	Island	location	Lat./Long.[a]	Transect	Comments
American Oystercatcher	Ocean Isle	Shallotte Inlet	33° 90′ 40.78179″ N 78° 38′ 77.04487″ W	12 E-M	Nest with 2 eggs 13 May.
Willet	Ocean Isle	Shallotte Inlet	33° 90′ 38.95738″ N 78° 38′ 72.70023″ W	12 W	1 bird on territory 20 May. 2 birds on territory 30 May. Eggshell pieces and depression found within 8-12 ft. of location where 2 birds spotted on territory 4 Jul.

[a] Nest locations or approximate nesting sites were determined with Trimble PRO XR GPS unit.

Table 13. Summary of recorded disturbances for each transect.

	Transect #	
Type of disturbance	12	13
Humans	45	40
Pets	6	3
Number of surveys	46	40
Average number of people per survey	31.17	73.23
Percent of surveys with a disturbance	97.83	100.00
Percent of disturbances with a pet	13.04	7.50

Table 14. Summary of piping plover observations.

Transect #	Total observations	Transect segment				Habitat Use			Activity			
		East	East-middle	West	West-middle	Intertidal	Beach	Dune	Resting	Feeding	Flying	Breeding
1	1	0	0	1	0	1	0	0	0	1	0	0
2	1	0	0	0	1	1	0	0	0	1	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0
4	26	0	0	14	12	18	8	0	7	17	2	0
5	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	2	0	2	0	0	0	2	0	0	2	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
11	20	14	3	3	0	15	5	0	4	16	0	0
12[a]	7	1	6	0	0	7	0	0	0	7	0	0
13[a]	0	0	0	0	0	0	0	0	0	0	0	0
Totals	57	15	11	18	13	42	15	0	11	44	2	0

[a] Transect at Ocean Isle.

Table 15. Summary of all waterbird data by transect.

Transect#	Island	Site	Total # Species	Total Individuals	Avg. # species/ survey	Avg. # individuals/ kilometer/ survey	Percentage of birds						
							Habitat Use			Activity			
							Intertidal	Beach	Dune	Resting	Feeding	Flying	Breeding
1	Bald Head	Cape Fear	27	11,287	7.37	152.5	78.5	19.6	1.9	55.9	7.4	36.7	0.0
2	Bald Head	South Beach	16	2,192	5.18	34.1	73.0	10.5	16.5	26.9	11.9	61.3	0.0
3	Bald Head	River Cape	25	10,450	7.28	94.1	79.0	14.0	6.9	60.3	4.5	35.2	0.0
4	Oak Island	Caswell	24	9,210	7.58	95.4	89.0	3.9	7.2	57.4	6.6	36.0	0.0
5	Oak Island	East Beach	22	10,587	6.80	164.5	55.7	29.6	14.7	51.1	7.3	41.7	0.0
6	Oak Island	West Beach	15	10,103	6.00	157.0	57.7	27.3	15.0	54.1	8.1	37.8	0.0
7	Oak Island	Lockwoods	22	13,292	7.76	119.7	67.2	21.6	11.3	57.6	4.9	37.4	0.0
8	Holden	Lockwoods	22	9,208	7.17	124.4	72.2	13.8	14.0	42.4	6.4	51.2	0.0
9	Holden	East Beach	18	11,013	6.08	171.1	64.0	21.8	14.2	47.7	11.1	41.3	0.0
10	Holden	West Beach	18	5,383	5.83	83.6	57.6	20.5	22.0	42.8	8.1	49.1	0.0
11	Holden	Shallotte Inlet	29	8,838	9.13	59.7	85.4	7.1	7.5	49.1	7.5	43.4	0.0
12	Ocean Isle	Shallotte Inlet	26	10,747	8.39	133.7	87.5	7.1	5.4	64.6	6.1	29.3	0.0
13	Ocean Isle	East Beach	15	4,197	5.50	65.2	40.2	33.5	26.4	27.0	10.0	63.0	0.0

Table 16. Summary of all shorebird data by transect.

Transect#	Island	Site	Total # Species	Total Individuals	Avg. # species/ survey	Avg. # individuals/ kilometer/ survey	Percentage of birds						
							Habitat Use			Activity			
							Intertidal	Beach	Dune	Resting	Feeding	Flying	Breeding
1	Bald Head	Cape Fear	14	1,143	2.59	15.4	94.6	5.2	0.2	11.3	76.2	12.4	0.1
2	Bald Head	South Beach	10	511	1.95	7.9	95.1	3.3	1.6	9.6	75.7	14.7	0.0
3	Bald Head	River Cape	14	3,695	3.91	33.3	73.2	26.5	0.3	54.2	34.9	10.9	0.1
4	Oak Island	Caswell	14	1,953	3.40	20.2	96.6	2.4	1.0	60.7	31.4	7.7	0.3
5	Oak Island	East Beach	14	685	2.68	10.6	83.8	15.9	0.3	11.4	75.8	12.6	0.3
6	Oak Island	West Beach	10	678	2.28	10.5	80.1	18.4	1.5	12.4	67.1	20.5	0.0
7	Oak Island	Lockwoods	20	7,001	4.22	63.0	54.8	44.9	0.3	75.1	16.4	8.5	0.1
8	Holden	Lockwoods	14	2,406	3.07	32.5	80.6	18.7	0.7	66.4	24.9	8.7	0.0
9	Holden	East Beach	10	1,021	2.83	15.9	86.6	13.1	0.3	17.4	70.5	12.0	0.0
10	Holden	West Beach	11	1,043	2.93	16.2	87.9	9.6	2.5	16.8	69.5	13.7	0.0
11	Holden	Shallotte Inlet	18	3,863	4.78	26.1	69.6	27.6	2.8	55.8	27.7	16.5	0.1
12	Ocean Isle	Shallotte Inlet	22	1,789	4.43	22.3	84.0	15.4	0.7	34.3	36.3	29.3	0.1
13	Ocean Isle	East Beach	11	874	2.40	13.6	85.7	10.1	4.2	13.0	60.2	26.8	0.0

APPENDICES

APPENDIX A

DESCRIPTIONS OF FEATURES AND COORDINATES ALONG TRANSECTS FOR OCEAN ISLE BEACH, NC BIRD SURVEYS

Appendix A. Descriptions of features and coordinates along Transects 12 and 13 for Ocean Isle Beach, NC Bird Surveys.

Transects for Ocean Isle Beach, Brunswick County, NC Bird Surveys

Transect ID[a]	Easting[b]	Northing[b]	CZR GPS Label	Comments / visual aids
TRANSECT #12				
Ocean Isle Beach - Shallotte Inlet				just over 1 mile long, 1433 feet per section
East end	2185062.317	56656.942	12tr14	soundside end of transect/sandy beach, across from trailer/camper park along ICWW
Quarter point	2186236.773	57024.759	12tr18	near soundside point/inlet, near where red bouy lines with a mainland house
Mid point	2186094.546	55821.891	12tr22	just north of last lone red cedar shrub in low dune line
Three-quarter point	2185122.950	54783.254	12tr24	where shrub thicket approaches beach/erosion, just east of last houses
West end	2183887.062	54114.324	12tr01	beach crossing at the south end of Shallotte Blvd.
TRANSECT #13				
Ocean Isle Beach - beach				1 mile long
East end	2177206.569	52297.061	13tr05	just west of beach access, 4-window cottage (#242) near double "keep off dunes" signs
Quarter point	2175949.302	51891.368	13tr04	3 houses east of large pink cottage, low cottage w/lt. Grey shingles & picket rail porch
Mid point	2174699.151	51468.054	13tr03	2 houses west of peach cottage w/3 levels of white porches, low cottage between flag poles
Three-quarter point	2173441.793	51062.822	13tr02	cottage #92, 3 houses west of wide green 2-story cottage w/white trim
West end	2172183.416	50662.308	13tr01	beach crossing at south end of Monroe Street

[a]Transects were established with a Trimble Pro XRS GPS unit.
Transects were divided into four sections and identified in the field with red "pin flags" on the dune.
Each of the four segments for each transect will be designated with "east, east-middle, west-middle, west" representing each segment.

APPENDIX B

SUMMARY OF SURVEY DATES OF ALL TRANSECTS

Appendix B. Summary of survey dates of all transects.

	Ocean Isle Beach Transect	
Week #	12	13
48	13-Dec-01	13-Dec-01
49	28-Dec-01	28-Dec-01
50	10-Jan-02	10-Jan-02
51	24-Jan-02	24-Jan-02
52	8-Feb-02	8-Feb-02
53	22-Feb-02	22-Feb-02
54	28-Feb-02	28-Feb-02
55	7-Mar-02	7-Mar-02
56	15-Mar-02	15-Mar-02
57	18-Mar-02	18-Mar-02
58	26-Mar-02	26-Mar-02
59	1-Apr-02	1-Apr-02
60	8-Apr-02	8-Apr-02
61	17-Apr-02	17-Apr-02
62	23-Apr-02	23-Apr-02
63	3-May-02	3-May-02
64	8-May-02	6-May-02
65	13-May-02	13-May-02
66	20-May-02	20-May-02
67	30-May-02	30-May-02
68	5-Jun-02	
69	12-Jun-02	
70	20-Jun-02	
71	28-Jun-02	
72	4-Jul-02	
73	13-Jul-02	
74	17-Jul-02	17-Jul-02
75	22-Jul-02	22-Jul-02
76	29-Jul-02	29-Jul-02
77	5-Aug-02	5-Aug-02
78	12-Aug-02	12-Aug-02
79	19-Aug-02	19-Aug-02
80	26-Aug-02	26-Aug-02
81	2-Sep-02	2-Sep-02
82	9-Sep-02	9-Sep-02
83	16-Sep-02	16-Sep-02
84	23-Sep-02	23-Sep-02
85	30-Sep-02	30-Sep-02
86	7-Oct-02	7-Oct-02
87	14-Oct-02	14-Oct-02
88	21-Oct-02	21-Oct-02
89	28-Oct-02	28-Oct-02
90	4-Nov-02	4-Nov-02
91	11-Nov-02	11-Nov-02
92	18-Nov-02	18-Nov-02
93	26-Nov-02	26-Nov-02

APPENDIX C

COMPLETED DATA SURVEY FORMS
(December 2001 through November 2002)

Appendix C is available for review and on file
with the Wilmington District Corps of Engineers
and CZR Incorporated

APPENDIX D

TOTAL NUMBER OF WATERBIRD SPECIES DURING EACH SURVEY BY TRANSECT

Appendix D. Total number of waterbird species recorded during each survey by transect.

	Ocean Isle Beach Transect	
WEEK #	**#12 - Inlet**	**#13 - Beach**
48	8	8
49	7	7
50	4	6
51	4	4
52	6	6
53	5	3
54	3	5
55	8	4
56	7	4
57	6	6
58	8	6
59	8	2
60	9	5
61	2	3
62	11	7
63	10	4
64	10	5
65	10	7
66	9	6
67	7	8
68	7	-
69	8	-
70	9	-
71	10	-
72	7	-
73	11	-
74	8	6
75	8	7
76	10	5
77	11	5

	Ocean Isle Beach Transect	
WEEK #	#12 - Inlet	#13 - Beach
78	7	3
79	9	7
80	11	6
81	9	4
82	12	6
83	12	5
84	12	4
85	11	5
86	11	4
87	11	6
88	9	8
89	10	6
90	7	8
91	10	8
92	7	6
93	7	5
Total	386	220
Average species/ survey	8.39	5.50

"—" = no survey

APPENDIX E

TOTAL NUMBER OF WATERBIRD INDIVIDUALS DURING EACH SURVEY BY TRANSECT

Appendix E. Total number of waterbird individuals recorded during each survey by transect.

	Ocean Isle Beach Transect	
WEEK #	**#12 - Inlet**	**#13 - Beach**
48	42	67
49	174	83
50	118	43
51	37	47
52	56	114
53	34	75
54	27	26
55	44	89
56	58	150
57	70	72
58	77	114
59	292	62
60	199	145
61	42	107
62	90	176
63	197	171
64	226	104
65	71	145
66	337	46
67	32	142
68	79	-
69	55	-
70	76	-
71	101	-
72	287	-
73	197	-
74	105	79
75	546	293
76	194	78
77	190	159

	Ocean Isle Beach Transect	
WEEK #	#12 - Inlet	#13 - Beach
78	97	59
79	157	69
80	213	65
81	150	42
82	393	79
83	384	90
84	1113	134
85	413	32
86	741	46
87	251	68
88	462	115
89	459	130
90	161	93
91	267	93
92	77	209
93	1356	286
Total	10747	4197
Average birds/ survey	233.63	104.93

"—" = no survey

APPENDIX F

TOTAL NUMBER OF SHOREBIRD SPECIES DURING EACH SURVEY BY TRANSECT

Appendix F. Total number of shorebird species recorded during each survey by transect.

	Ocean Isle Beach Transect	
WEEK #	**#12 - Inlet**	**#13 - Beach**
48	4	2
49	3	2
50	3	0
51	1	2
52	1	0
53	2	1
54	2	1
55	4	2
56	3	2
57	4	0
58	4	2
59	3	2
60	2	2
61	2	2
62	4	4
63	9	2
64	8	3
65	7	4
66	10	2
67	5	6
68	2	-
69	4	-
70	1	-
71	3	-
72	1	-
73	1	-
74	0	1
75	3	2
76	6	2
77	4	3

	Ocean Isle Beach Transect	
WEEK #	#12 - Inlet	#13 - Beach
78	6	3
79	5	4
80	10	3
81	4	2
82	10	5
83	6	4
84	9	2
85	7	2
86	5	2
87	3	2
88	7	3
89	5	3
90	4	2
91	4	4
92	7	3
93	6	3
Total	204	96
Average species/ survey	4.43	2.40

"—" = no survey

APPENDIX G

TOTAL NUMBER OF SHOREBIRD INDIVIDUALS DURING EACH SURVEY BY TRANSECT

Appendix G. Total number of shorebird individuals recorded during each survey by transect.

	Ocean Isle Beach Transect	
WEEK #	**#12 - Inlet**	**#13 - Beach**
48	19	6
49	7	7
50	25	0
51	2	8
52	3	0
53	3	4
54	4	8
55	58	7
56	8	14
57	8	0
58	6	2
59	20	7
60	7	9
61	3	6
62	12	22
63	323	10
64	69	21
65	41	39
66	218	22
67	28	133
68	7	-
69	29	-
70	1	-
71	5	-
72	4	-
73	1	-
74	0	7
75	7	4
76	53	10
77	13	27

	Ocean Isle Beach Transect	
WEEK #	**#12 - Inlet**	**#13 - Beach**
78	24	23
79	36	27
80	59	27
81	20	15
82	87	35
83	24	56
84	51	33
85	36	23
86	24	40
87	11	32
88	106	39
89	44	28
90	87	19
91	22	21
92	144	27
93	30	56
Total	1789	874
Average birds/ survey	38.89	21.85

"—" = no survey

APPENDIX H

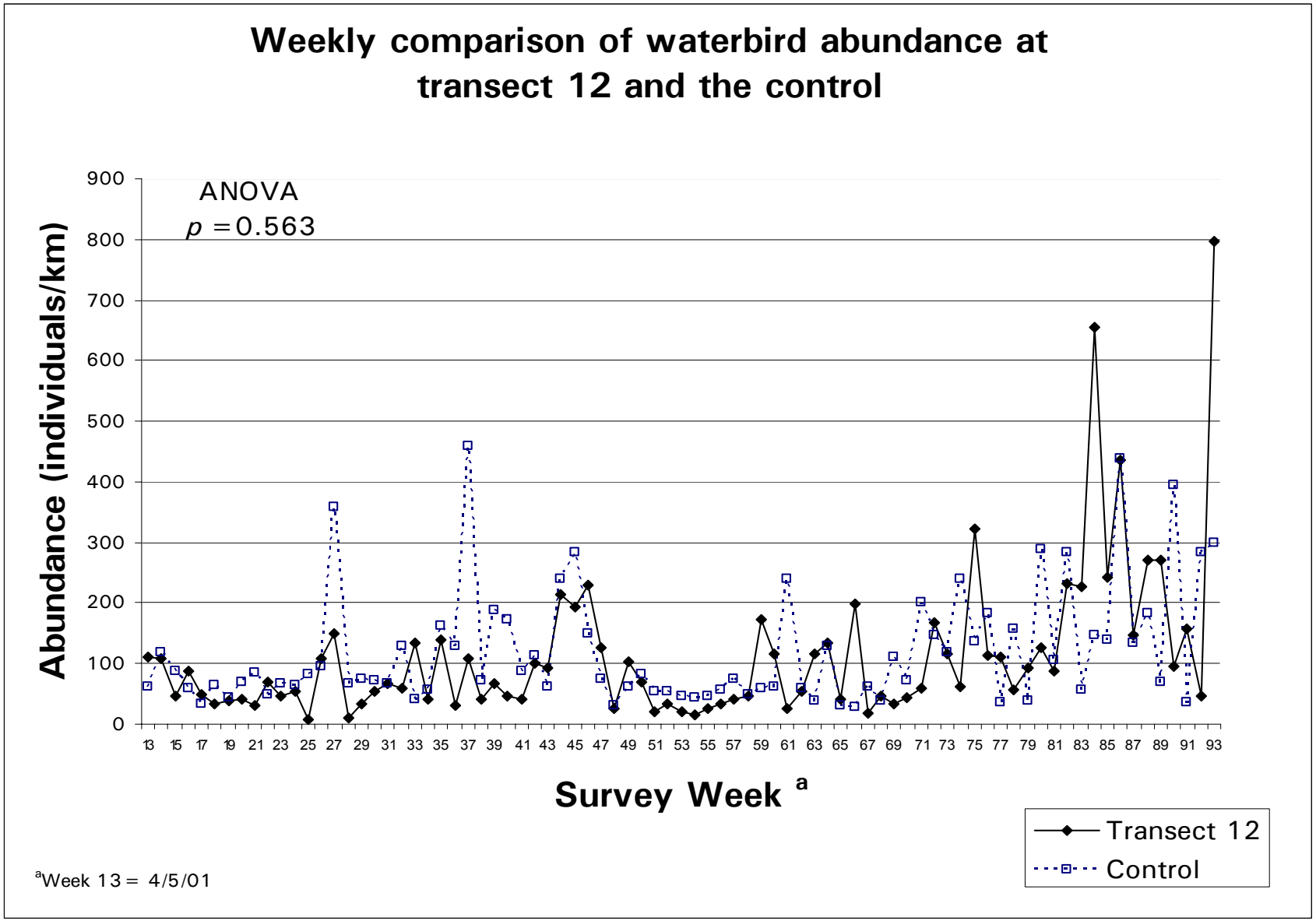
SUMMARY NOTES ON NESTING CHRONOLOGY OF BREEDING OR SUSPECTED BREEDING BIRDS ALONG TRANSECTS 12 AND 13, OCEAN ISLE BEACH, NC

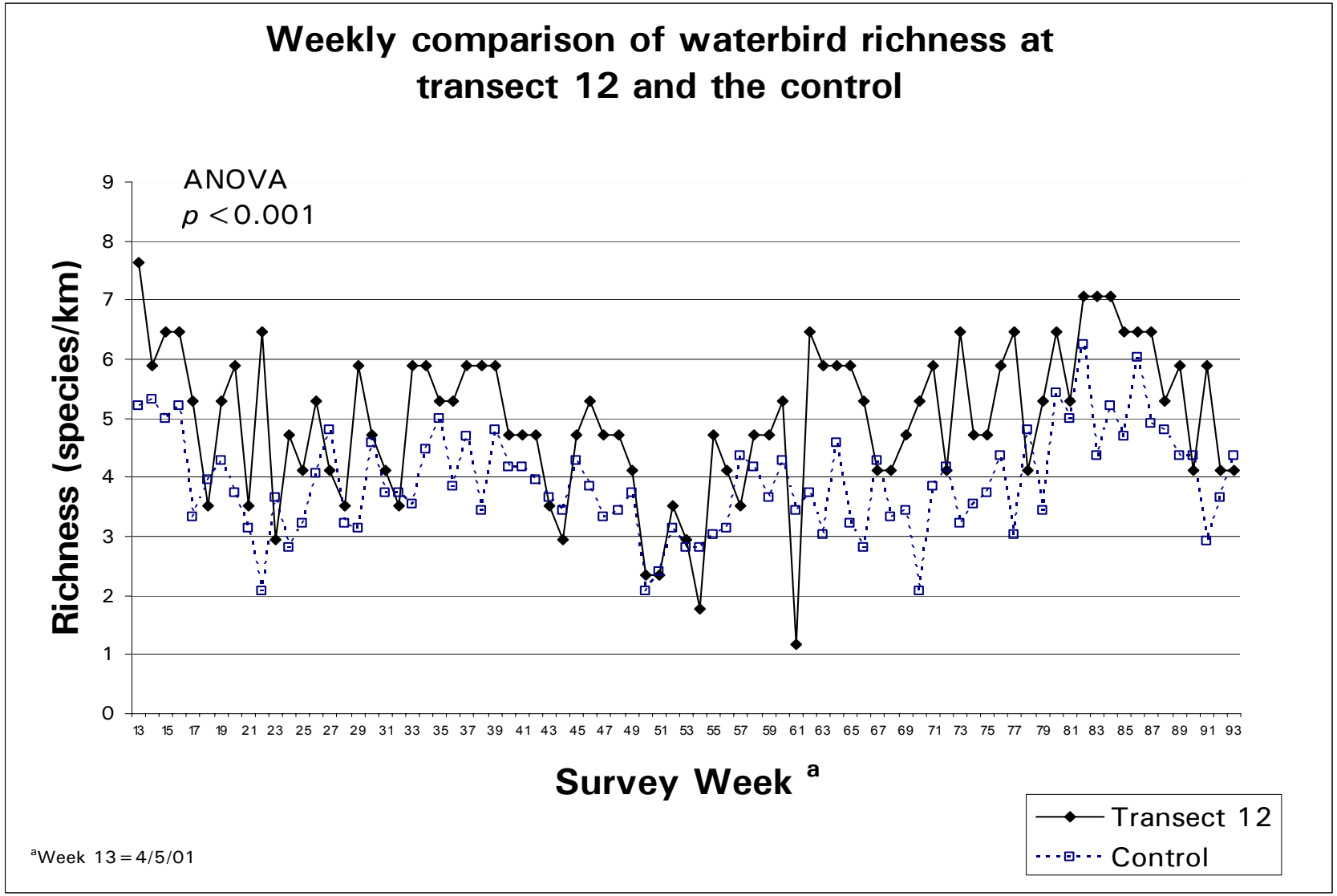
Appendix H. Summary notes on nesting chronology of breeding or suspected breeding birds along Transects 12 and 13, Ocean Isle Beach, NC.

Species	Island	Transect	Date	Courtship/displays	Eggs/nests
American Oystercatcher	Ocean Isle	12 E-M	13-May-02		Nest with 2 eggs
Willet	Ocean Isle	12 E	20-May-02	One bird on territory	
	Ocean Isle	12 W	30-May-02	Two birds on territory	
	Ocean Isle	12 W	4-Jul-02		Eggshell pieces and depression found within 8-12 ft. of location where 2 birds spotted on territory 30 May.

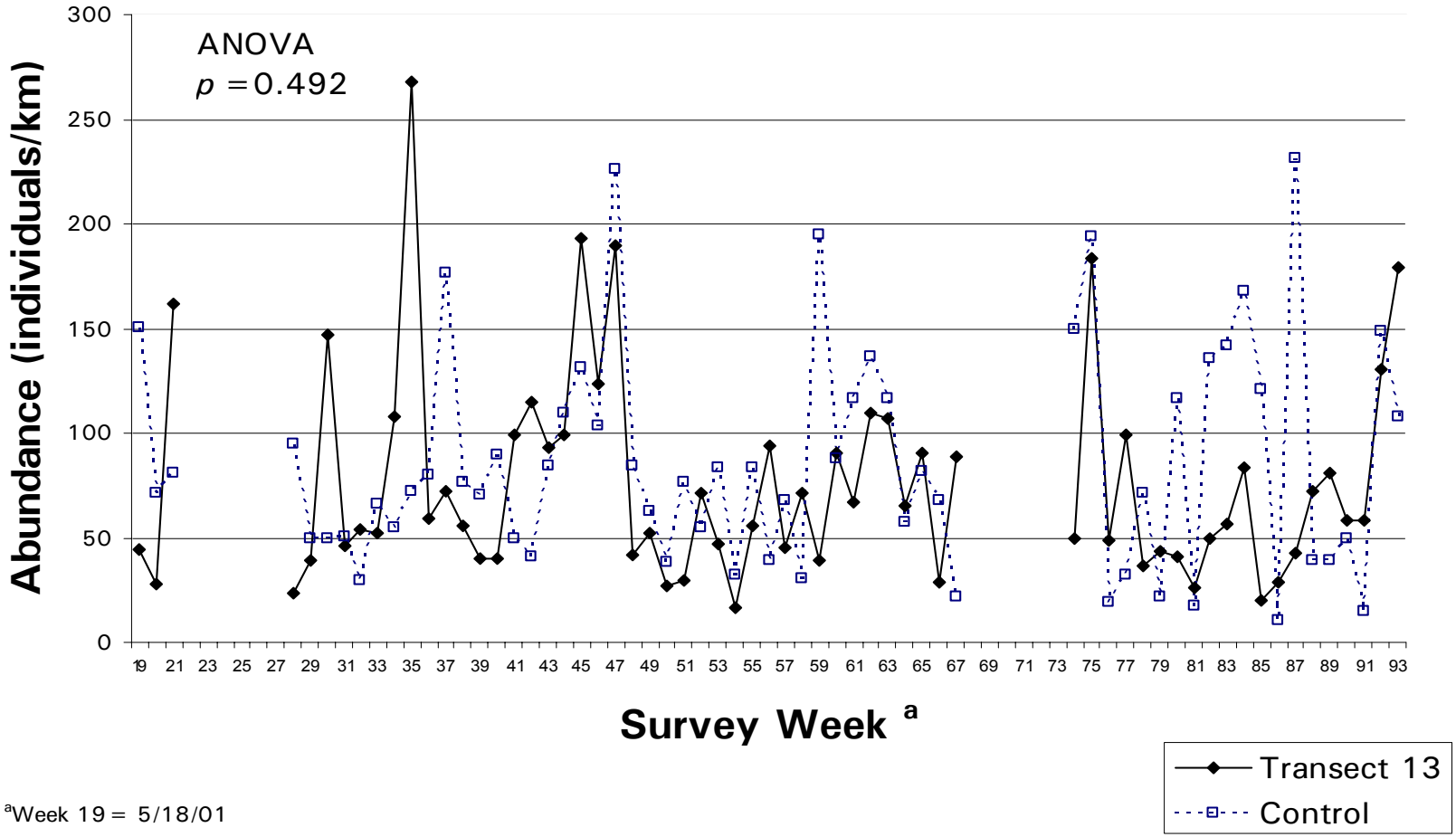
APPENDIX I

FIGURES DEPICTING WEEKLY WATERBIRD RICHNESS AND ABUNDANCE AT RENOURISHED TRANSECTS AND CONTROL AREAS

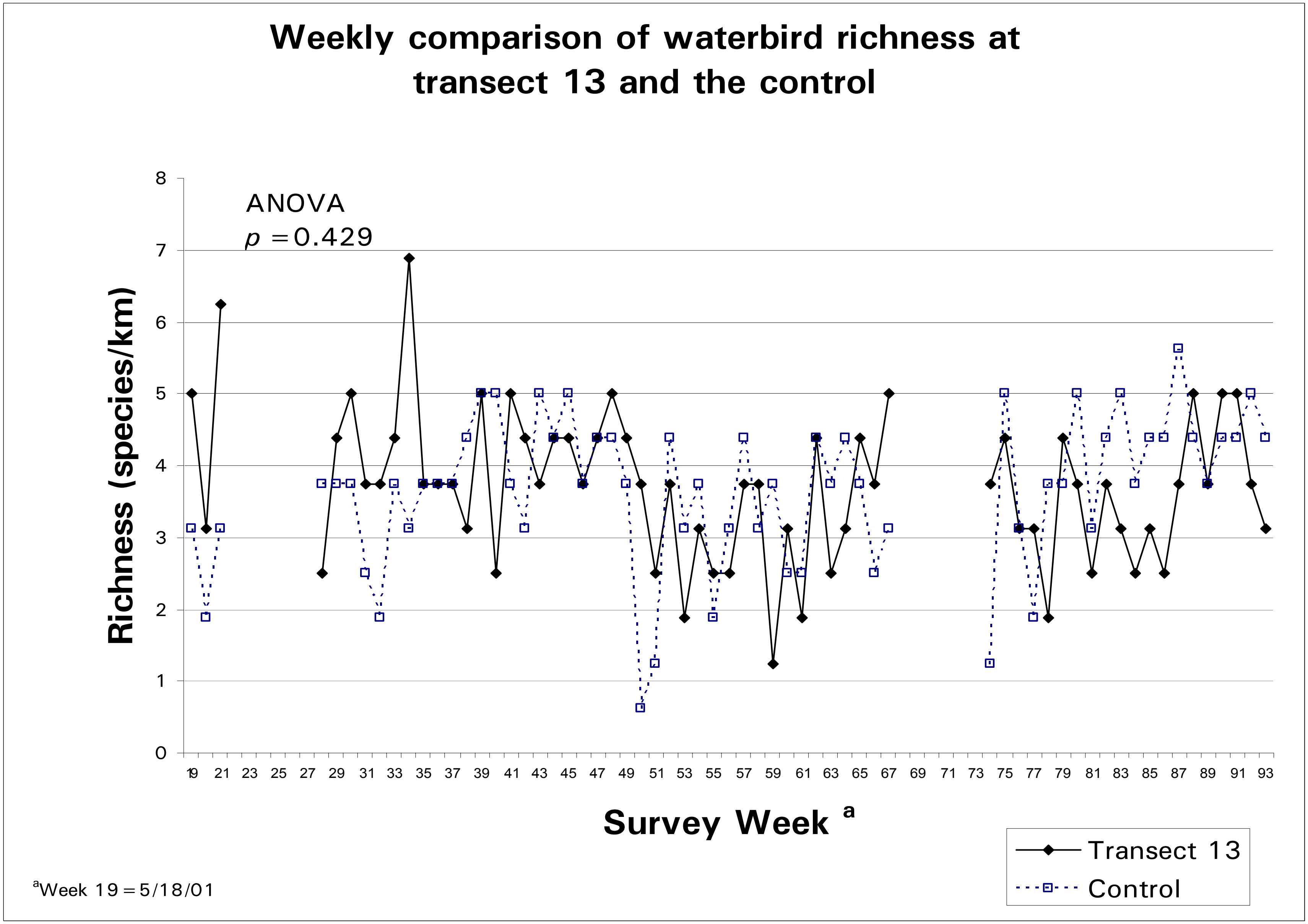

Weekly comparison of waterbird abundance at transect 12 and the control
ANOVA
p = 0.563
Abundance (individuals/km)
900
800
700
600
500
400
300
200
100
0
13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71 73 75 77 79 81 83 85 87 89 91 93
Survey Week a
Transect 12
Control
aWeek 13 = 4/5/01


Weekly comparison of waterbird richness at transect 12 and the control
ANOVA
p < 0.001
Richness (species/km)
0
1
2
3
4
5
6
7
8
9
13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71 73 75 77 79 81 83 85 87 89 91 93
Survey Week a
Transect 12
Control
aWeek 13 = 4/5/01

Weekly comparison of waterbird abundance at transect 13 and the control

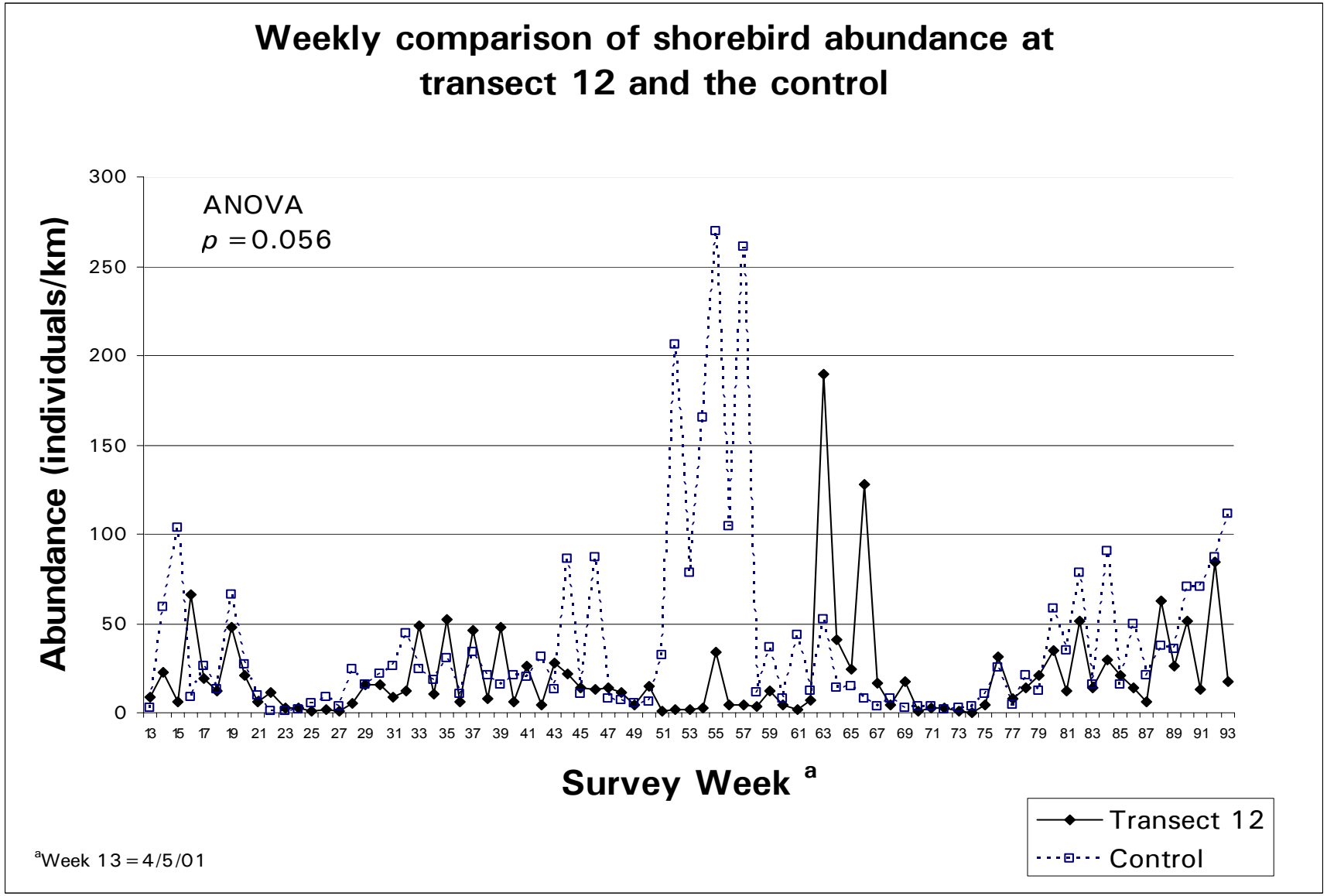


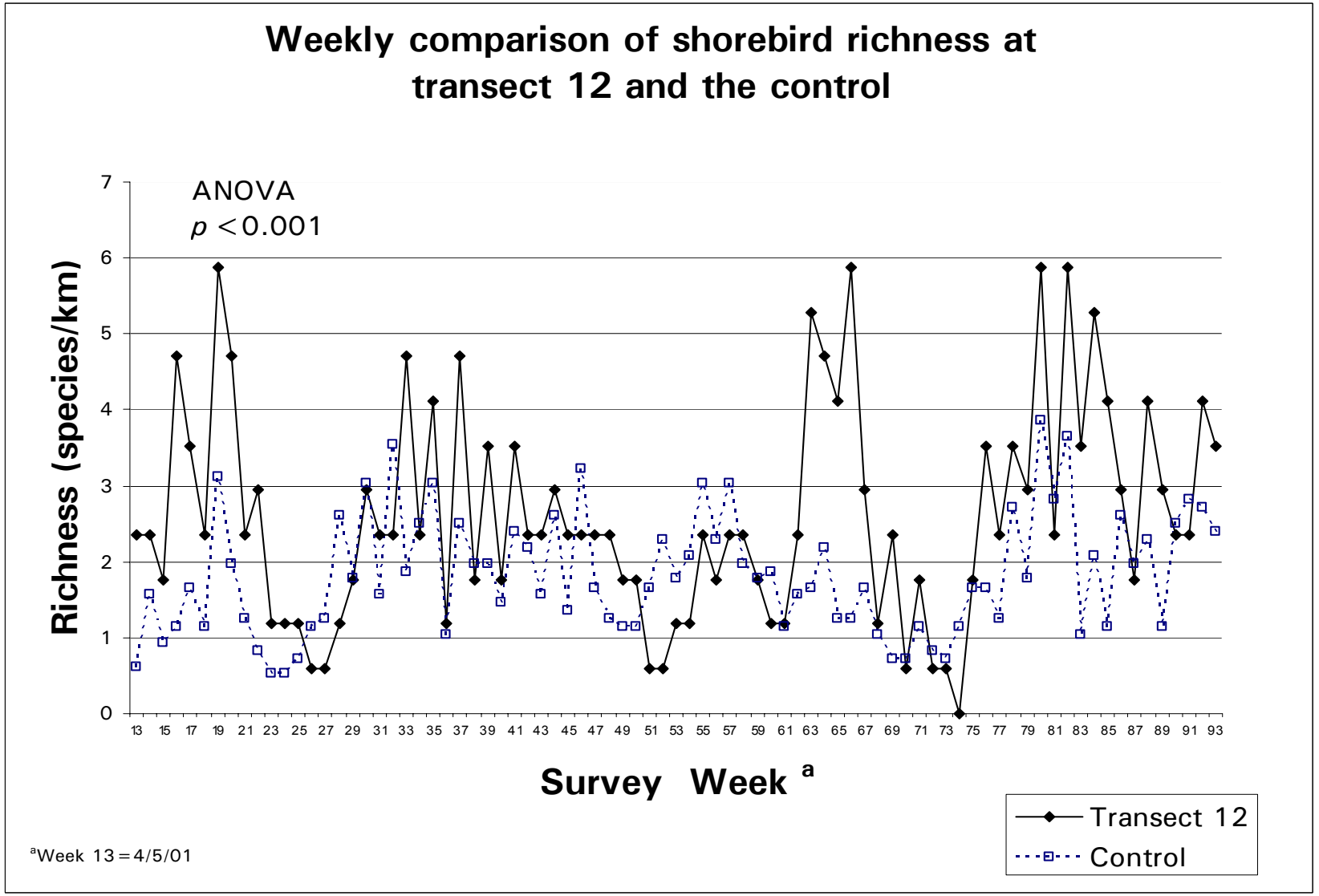
[a]Week 19 = 5/18/01


Weekly comparison of waterbird richness at transect 13 and the control
ANOVA
p = 0.429
Richness (species/km)
Survey Week a
Transect 13
Control
aWeek 19 = 5/18/01

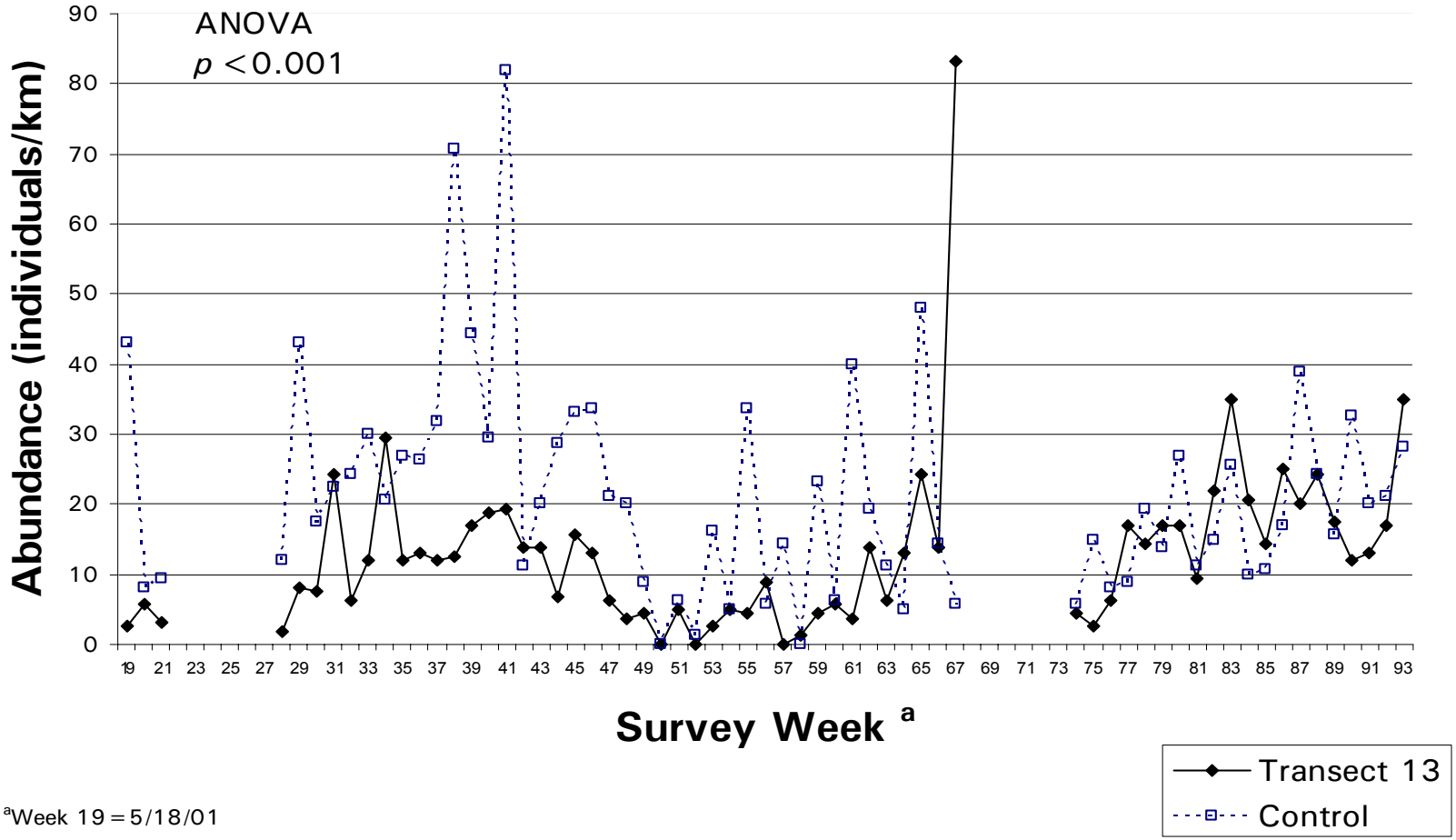
APPENDIX J

FIGURES DEPICTING WEEKLY SHOREBIRD RICHNESS AND ABUNDANCE AT RENOURISHED TRANSECTS AND CONTROL AREAS


Weekly comparison of shorebird abundance at transect 12 and the control
ANOVA
p = 0.056
Abundance (individuals/km)
300
250
200
150
100
50
0
13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71 73 75 77 79 81 83 85 87 89 91 93
Survey Week a
Transect 12
Control
aWeek 13 = 4/5/01

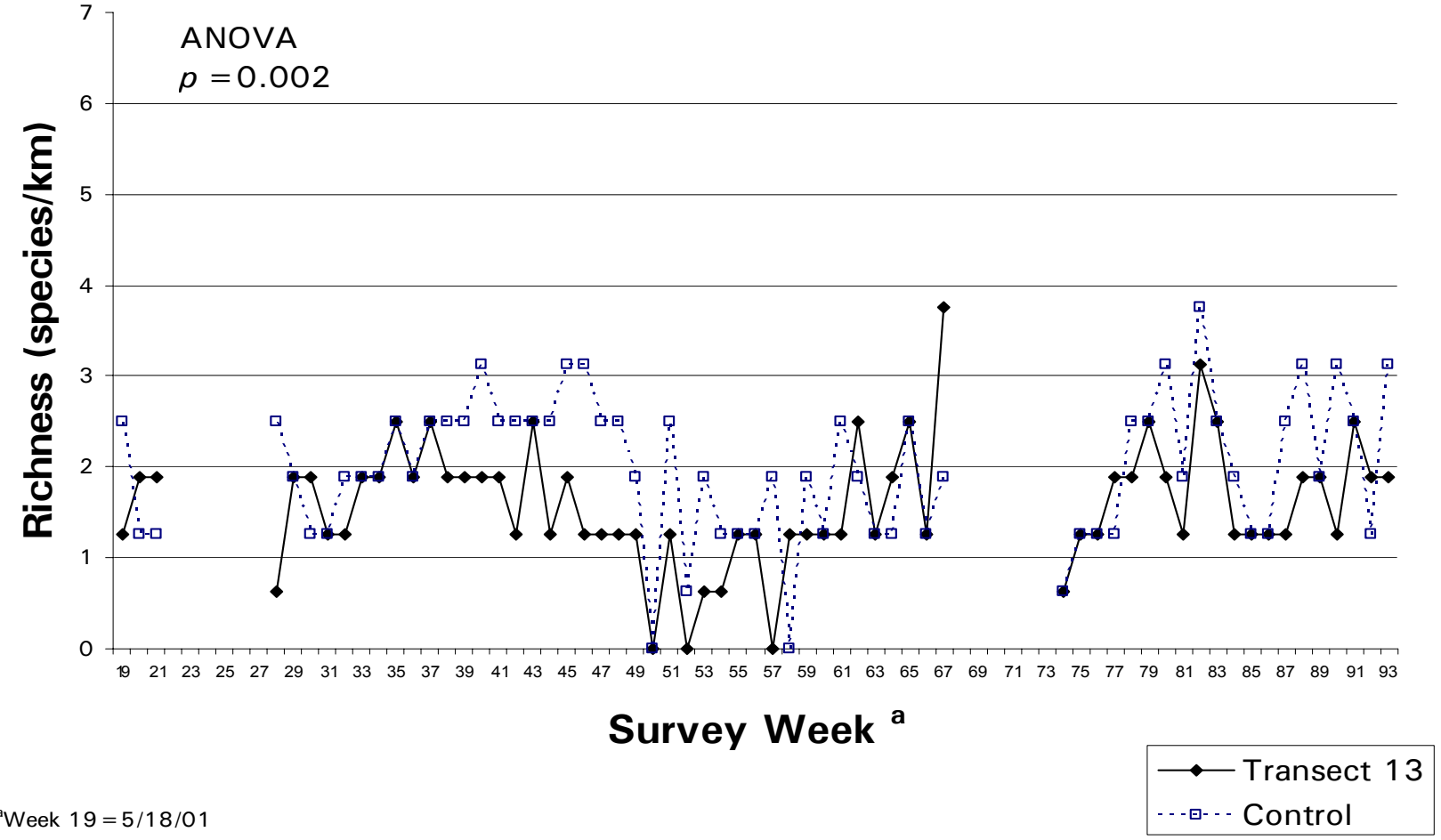

Weekly comparison of shorebird richness at transect 12 and the control
ANOVA
p <0.001
Richness (species/km)
0
1
2
3
4
5
6
7
13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71 73 75 77 79 81 83 85 87 89 91 93
Survey Week a
Transect 12
Control
aWeek 13 = 4/5/01

Weekly comparison of shorebird abundance at transect 13 and the control



[a]Week 19 = 5/18/01

Weekly comparison of shorebird richness at transect 13 and the control



[a]Week 19 = 5/18/01